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INVESTIGATION ON BONE CONDUCTION IN THE ANIMAL AND IN THE HUMAN.*

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Chicago.

In a previous paper we reported on investigations on the middle ear muscle reflex and its value as a hearing indicator in animals. We believe that the animal experiment now furnishes new information with respect to problems that have not been solved either by clinical or histological investigations. Bone conduction is one of these problems. In this country evidence has been presented which seems to indicate that an absolute increase in bone conduction does not exist. It has been assumed that in making tests on bone conduction in a room which fails to be soundproof, the noise in the environment has a marked influence on the results. Besides the masking effect of noise, another difficulty of the clinical test consists in the fact that very slight changes of the inner ear might be overlooked in a patient with a marked middle ear lesion. Therefore the advantage of the animal experiment with artificially produced lesions, the site and size of which can always be checked histologically, is obvious.

Investigations on the middle ear muscle reflex due to bone conducted sounds had previously been carried out only by

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Luescher.* Our experiments were started under the following headings:

1. Is there an acoustic middle ear muscle reflex due to bone conducted sounds?

2. Is it possible to study the Rinné, Weber and Schwabach test in animals?

3. Is there a real increase of bone conduction due to lesions of the middle ear?

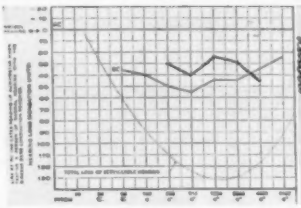
When we started our experiments we assumed that the negative result obtained by Luescher with tuning forks may be due to the insufficient intensity of the tuning fork. In order to produce a powerful irritation we used an applicator or oscillator with amplifier, as used in the hearing aids that work by bone conduction. The acoustic irritations consisted in pure tones, as produced by a Western Electric 2A Audiometer, and also the voice. In the first case the receiver of the audiometer is fixed in front of the microphone of the bone conduction apparatus. The application was carried out on different parts of the skull. The most favorable place seemed to be the teeth. Therefore, most of the animal experiments have been performed with the applicator on the teeth of the upper jaw. There was a definite middle ear muscle reflex due to bone conduction in 512, 1024 and 2048. The lower and higher frequencies did not show a reflex. In order to have a reading of the tensor contractions covering the whole range producable by the audiometer, it was necessary to amplify the sound before sending it into the bone conduction apparatus. With this double amplification the following curve was obtained (see Curve 1). In some frequencies the applicator produced a certain sound audible also by air conduction. Therefore, it was necessary to determine to what degree this sound irritated the inner ear by air conduction. As a suitable test the following procedure was carried out: After the reading of the tensor was taken the applicator was lifted away from the teeth of the animal and the reading repeated. As the applicator is removed from the teeth the tensor reflex disappears, in spite of the fact that the audible sound is greatly increased. Much stronger sounds, however, do show a reflex due to air conduction. In the experiment which is shown

* Luescher: Zeitschrift. fur Hals-, Nasen- und Ohrenheilkunde, Vol. 25, p. 462, 1929.

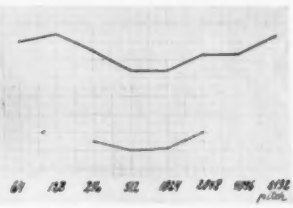
in Curve 1, one had to shift the dial of the audiometer about 30 db. or even more before an air conducted sound produced a reflex. Further proof that the reflex occurs in response to the bone conducted sound is given by the experiments carried out on rabbits with artificial lesions of the middle ear.

OBSERVATIONS IN MAN.

The middle ear muscle reflex due to bone conduction was also studied in the human. As we published in a former paper, it is quite possible to take the threshold curve of the stapedius contraction in patients who possess a visible stapedius tendon. Patients with a defect in the eardrum permitting observation of the stapedius tendon are not rare and several



Curve 1.



Curve 2.

Curve 1. Threshold of the tensor due to bone conducted sounds in a rabbit. Sound production by Western Electric 2A Audiometer connected with an amplifier and a bone conduction hearing aid apparatus. Oscillator at the root of the nose.

Curve 2. Pat. T. C. Threshold of the stapedius contraction due to bone conducted sounds. The upper line indicates the hearing sensation, the lower line the reflex threshold. Note the parallel course.

have been studied. As a matter of fact, not all patients show movements of their stapedius tendon. This may be explained by adhesions impairing the mobility of the tendon or to a greatly reduced threshold of hearing. In several cases, however, we have been able to observe the stapedius reflex due to bone conduction in man. Curve 2 gives the hearing curve and the stapedius curve by bone conduction. Definite movements were seen only for a few pitches. However, from the animal experiment we may conclude that the lack of reflex movements in the lower pitches is only due to the insufficient intensity of the sound.

The bone conduction reflex could be started from different parts of the skull. Curve 3 shows the threshold of both hear-

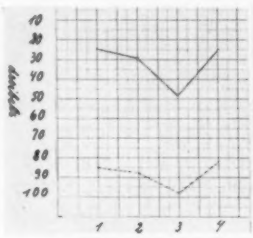
ing ability and stapedius reflex taken from different parts of the skull. The procedure of taking these readings is as follows: First, the sound applicator was attached to the mastoid process and the threshold of hearing recorded. Then the stapedius tendon was observed and the threshold of the muscle contraction read, the bone conduction applicator remaining in the same position. The threshold varies as Curve 3 shows with the different sites of the sound application. However, the threshold of hearing and the threshold of the muscle contraction are absolutely parallel. The quantitative determination of the differences between the two curves cannot be given exactly, since the bone conduction applicator amplifies the sound to an unknown degree. We have expressed the intensity in terms of decibels as recorded on the audiometer. It is obvious that the amplification shifts the number of decibels by an unknown factor. However, the final intensity delivered by the sound applicator or oscillator maintains a definite proportion to the intensity recorded on the audiometer.

The parallel course of the two curves may be taken as a further proof for the close relationship between hearing sensation and muscle contraction. On the other hand, the intimate conformity between the findings in rabbits and in man, so far as the physiology of the middle ear is concerned, is shown in these experiments.

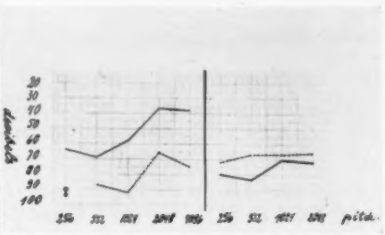
EXPERIMENTS ON THE RINNÉ TEST.

After definite information as to the irritability of the middle ear muscles due to bone conducted sounds had been obtained, experiments were started dealing with pathological conditions. Artificial lesions were performed on the sound conduction apparatus of the rabbit and readings of the muscles were taken. While comparing the reading by air conduction with those of bone conduction we had the conditions of the clinical Rinné test. The Schwabach test was also investigated by comparing the bone conduction reflex before and after an artificial lesion of the middle ear. The Weber test cannot be carried out experimentally for the following reasons: The middle ear muscle reflex in either ear is produced almost equally by either labyrinth. Besides this physiological reason there is a psychological reason, which involves the very nature of the Weber test. Let us assume that we have a patient with a slight inner ear lesion. This patient will local-

ize the Weber into the good ear. The fact that he has no hearing sensation in his bad ear does not mean that there is no irritation in this ear. The explanation is that the sensation is shifted into the other ear, due to a psychological effect; incidentally, the same psychological condition which is responsible for the Stenger test. We have here conditions where hearing sensation and acoustic irritation are dissociated. Under these conditions the middle ear muscle reflex fails to be a true mirror picture of the hearing sensation.



Curve 3.



Curve 4.

Curve 3. Comparison between hearing sensation and stapedius contraction. With the oscillator of our sound producing apparatus on four different points of the skull, both the hearing sensation and the threshold of the stapedius is measured. The four different points of the skull are: No. 1, mastoid process; No. 2, 1½ in. above the middle of the zygomatic arch; No. 3, upper posterior part of the parietal bone; No. 4, ½ in. anterior to the tragus.

Curve 4. Comparison between air conduction and bone conduction in a rabbit before and after instillation of fluid into the bulla ossea. Sound applicator for bone conduction on the teeth, for air conduction at the pinna. The left part of the curve is the air conduction, the right part the bone conduction. The dotted line indicates the threshold after the alteration. Note the downward trend of the air conduction and the upward trend of the bone conduction.

The following lesions have been produced in the experimental animal: *1.* Plugging of the outer acoustic canal representing the conditions in man with cerumen obturans. *2.* Filling the bulla ossea with fluid, thus resembling middle ear catarrh. *3.* Partial destruction of the ossicular chain; for instance, perforation of the eardrum, destruction of the incudostapedial junction, luxation or extirpation of the incus, thus producing conditions comparable to a large number of patients with chronic suppurative middle ear lesions. Some of these procedures have the advantage of being reversible, in that a reading can be taken not only before the lesion has been produced, but may also be rechecked after removal of

the lesion. This procedure can be repeated. Its importance is evident if only slight changes can be expected. The repeated investigation assures results which otherwise would not be reliable (see Table I).

In order to study the Rinné test in the animal the threshold for air conduction was taken first and then the threshold for bone conduction. Since the sound producing apparatus for air conduction and bone conduction is not the same we cannot compare the two thresholds from the quantitative standpoint. But this is also true in the clinical Rinné test, where the prongs and the stem of the tuning fork are different sound producers with different physical qualities.

Having determined the normal thresholds, if one introduces any alteration in the sound conduction system, the hearing for air conduction goes down (see Curve 4) or even disappears (see Curve 5) entirely. At the same time the hearing for bone conduction does not show any impairment, but even is improved to some extent. Curve 4 shows the two opposite trends which the hearing ability for air and bone conduction undergoes after fluid had been installed into the bulla ossea. Our experiments show that these functional changes take place regardless of the nature of the lesion to the conductive apparatus. The plug in the outer acoustic meatus has the same influence as the destruction of the ossicles or the instillation of fluid into the middle ear. However, the degree of change may be different; for instance, the air conduction in the experiment shown in Curve 5 is absolutely lost for intensities produced by our apparatus. Plugging of the outer canal produces only a minor impairment.

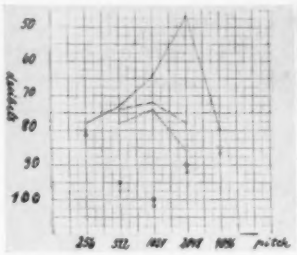
These experiments illustrate that the conditions of the Rinné test may be observed in the animal. Lesions of the sound conducting apparatus create conditions which alter the normal proportion between air and bone conduction so that finally the bone conduction may be better than the air conduction.

EXPERIMENTS ON THE SCHWABACH TEST IN ANIMALS.

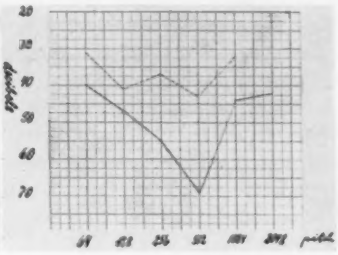
The experimental procedure for the Schwabach test in the animal is similar to that used for the Rinné test. The readings of the tensor are made before and after the lesion has been produced. The experiment possesses an advantage over

the clinical Schwabach, in that both readings are made on the same individual. This seems to be an advantage since normal differences between two individual persons might be overlooked clinically.

Our experiments show (see Curve 6) that the threshold for bone conducted sounds is lowered after lesions in the middle ear have been carried out. However, the improvement is only slight in some experiments. As stated above, some of the lesions on the sound conducting apparatus are reversible and can be repeated as often as one wishes. Table I gives



Curve 5.



Curve 6.

Curve 5. Comparison between air conduction and bone conduction before and after a middle ear lesion. Sound applicator for bone conduction on the teeth, for air conduction at the pinna. The uppermost line is the normal air conduction. After the lesion had been carried out, no air conducted reflex (indicated by arrows) remains. In contradistinction to this severe impairment of the air conduction, the bone conduction is slightly raised. Inferior broken line indicates the threshold of the bone conduction reflex before the alteration of the middle ear, upper broken line the threshold after lesion was produced. (Negative Rinné in the rabbit; — in the classical determination of Bezold.)

Curve 6. Schwabach test in the rabbit. Sound application at the teeth. Real increase of bone conduction due to severe bilateral middle ear lesion. The dotted line indicates the hearing after the alteration.

the threshold contractions of the tensor for bone conduction with normal outer acoustic meati and with the outer canals plugged with cotton.

TABLE I.

Frequency	First Normal Reading	Cotton Plug in the Outer Canal	Plug Removed Second Normal Reading	Second Plugging	Plug Removed Second Normal Reading
512	93	75	95	88	95
1024	75	67	77	73	77

The difference in the reading after the second plugging of the canal as compared with the first plugging is probably due to a different degree of occlusion by the cotton mass. The normal readings are practically constant.

In order to obtain a more accurate measurement of the differences in sound intensity used in these experiments a new recording method was devised. Instead of recording the differences in terms of decibels on the audiometer, they were recorded in terms of distance from the sound source to the microphone while keeping the intensity at the source a constant. We are, of course, well aware of the fact that this procedure might contain several sources of error because of physical reasons, such as acoustic conditions of the room. However, we consider the method rather more an estimation than an exact measurement. By giving figures we only wish to show the trend (improvement or impairment), due to lesions of the middle ear. The following table shows the threshold taken for bone conduction under normal conditions with the sound producer 15 cm. from the microphone. After the threshold is taken for all pitches under normal conditions the right incus was destroyed and the left bulla was filled with fluid. Then the threshold intensity as it was determined before for each pitch was produced. Under these conditions the observer could detect a definite marked increase in the degree of the tensor reflex. The sound producer was now moved away until the contraction was reduced to the threshold again. The degree of lowering of the threshold is now expressed in terms of centimeters distance.

TABLE II.

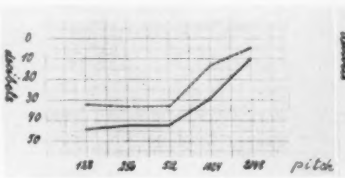
Frequency	Distance Before	Distance After Lesion of the Middle Ear Was Made
64	15 cm.	49 cm.
128	15 cm.	20 cm.
256	15 cm.	49 cm.
512	15 cm.	68 cm.
1024	15 cm.	72 cm.

As a test of this method the following reading was taken. The threshold was read with the sound producer at 10 cm. dis-

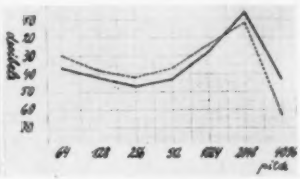
tance from the microphone. Then the sound producer was removed to a distance of 2.50 m. and the threshold again taken. As the table shows, the increase is constant.

TABLE III.

Frequency	Threshold in Db. in 10 Cm. Distance	Threshold in Db. in 2.50 M. Distance	Difference
256	38	52	14
512	42	55	13
1024	27	41	14



Curve 7.



Curve 8.

Curve 7. Hearing sensation curve of a normal person by bone conduction. Increase of the bone conduction due to plugging of the outer acoustic meatus. Observations made in a special hearing test room. Dotted line indicates the hearing sensation after the plugging. Note the corresponding increase in the bone conduction.

Curve 8. Schwabach test in man, taken with the audiometer. Observations carried out in a special hearing test room. Dotted line indicates the curve of the patient. The decrease of the patient's bone conduction in higher frequencies might be due to a slight inner ear component.

SCHWABACH TEST IN MAN.

Corresponding to the animal experiments a series of observations were carried out on man, using both the audiometer and tuning forks as a sound producer. Since the animal experiments show that artificial alterations of the sound conduction apparatus has qualitatively the same functional result regardless of the nature of the lesion, we assume that the plugging of the outer ear on a normal person has qualitatively the same functional result as a lesion of the ossicular chain or an exudate in the tympanic cavity.

Of great importance, of course, is the question of sound or noise in the testing room. The room used had been specially

constructed with soundproof ceiling, walls, windows, and doors. In addition the experiments were done in the late afternoon or evening when that part of the building was quiet. At this time no more sound was perceptible in the room than was produced by the inevitable movements or breathing of the people in the room itself. Under these conditions tests were made with the tuning fork, which showed how much longer the normal person heard the fork with the ears plugged than with the ears open. The average prolongation for three normal individuals with this particular tuning fork was 15 seconds.

The same procedure was carried out with an audiometer. Curve 7 shows the threshold for bone conduction with the ears open and with the ears closed.

A series of patients had been tested and gave the following result:

TABLE IV.

No.	Patient	Age	Diagnosis	Schwabach	
1	L. R. A.	15 yr.	Otitis media Suppurat. chron. bilat. quiescent	+40 +30	
2	D. W.	7 yr.	Radical mastoidectomy, right Otitis media suppurat. left	+10 +15	
3	D. Th.	14 yr.	Otitis media bilat. chron. suppurat. Large defect both M. T.'s	+40 +30 +42 +40	
4	M. R.	37 yr.	Otitis media suppurat. chron., bilat.	+45 +52 +45	+40 +30
5	Ch. W.	27 yr.	Otosclerosis	+35 +35	+20
6	Mrs. P. S	24 yr.	Otosclerosis bilat.	+35 +50	
7	W. A.	40 yr.	Radical mastoidectomy after otitis med. suppurat. chron. bilat. with aural polyp, left	+35 +37	
8	P. W.	29 yr.	Bilateral otitis media chron. with polyp in the left ear	+14 +20 +13	

The increase of bone conduction was also detected by the bone conduction hearing aid used in our experiments attached to the audiometer. Curve 8 shows the bone conduction of

patient No. 7 (Table IV) compared with that of a normal person. It should be mentioned again, that the curve only can show the fact that there is an increase of bone conduction. In Curves 7 and 8 the unit of the ordinate is the number of decibels as produced by the audiometer. However, the amplification which takes place in the bone conduction sound applicator is unknown to us. Therefore we cannot define the difference between the two curves in decibels.

DISCUSSION.

The finding that a middle ear muscle reflex occurs in response to bone conduction shows that the inner ear will send out the centripetal stimulus in response to acoustic irritation both by air and bone conducted sounds. The animal experiment has the advantage of having lesions, the site and extent of which are known to the investigator and which always can be checked by histological examination. On the other hand, a great number of the so-called clinical middle ear cases do have an inner ear component which definitely influences the bone conduction. This might be the case if one chooses patients with otosclerosis for studying the problem of bone conduction.

Our Rinné tests on rabbits show the same trend as we observe in the human. The proportion between air and bone conduction is changed in favor of the bone conduction. In very extensive middle ear lesions the hearing ability for air conduction was practically lost, but the reflex for bone conducted sounds was not only undiminished but definitely increased. These findings bring up the question: Does a real increase of bone conduction exist in middle ear diseases?

The observation that the increase in bone conduction depends to a large degree on the noise in the examining room is beyond question. However, the opinion that the noise in the surroundings accounts entirely for the increase in bone conduction has not been substantiated. On the contrary, Knudson and Jones* made the following statement in their interesting paper: "In the soundproof room if a plug of wax or water occludes the right external canal the Weber test is noticeably lateralized to the right ear. When the canal is occluded with wax the acuity of bone conduction of the right ear is increased 10 db."

*Knudson and Jones: Archives of Otolaryngology, Vol. 13, p. 489, 1931.

In these investigations the animal experiment with its reliable hearing indicator furnishes a new means of approaching the problem. In a former paper we stated that the tensor reflex is a rather true mirror-picture of the hearing sensation with the difference that the threshold of hearing lies at a lower level of sound intensity than the reflex. Since we observed a stronger reflex contraction after the middle ear lesion was made, we draw the conclusion that the irritation in the inner ear had been greater than before. Any influence of noise in the room on these findings seems very unlikely to us since such minute acoustic irritations have no effect at all so far as the tensor reflex is concerned.

Knudsen and Jones state in their paper that there is no theory to explain the increase in bone conduction under noise free conditions. In our opinion the experimental work by Krainz* offers a probable explanation of the mechanism by which the inner ear receives greater irritation by bone conduction in the presence of lesions of the conducting apparatus. As his experiments show, the phase shift between the bone and the ossicular chain changes with certain alterations of the sound conduction apparatus. If the phase-shift is diminished the hearing will be improved because an unfavorable factor is removed. Besides the phase the amplitude can undergo changes and produce greater inner ear irritation. Without going into details we only want to stress the point that there is a real increase in the irritation of the labyrinth due to plugging of the external acoustic meatus or due to lesions of the middle ear. The explanation relates to changes in the amplitude and phase of the sound waves reaching the labyrinth.

SUMMARY.

1. There is an acoustic tensor — and stapedius — reflex due to bone conduction in the rabbit.

2. Patients have been observed who show a stapedius reflex due to bone conduction.

3. Lesions of the sound conduction apparatus of the experimental animal (plugging of the outer ear, installation of fluid into the bulla, destruction of the ossicular chain) result in a definite decrease or even disappearance of the air conducted

*Krainz: Zeitschrift fur Hals- Nasen- und Ohrenheilkunde, Vol. 15, p. 306, 1926.

sound reflex. Since the bone conducted sound does not show a similar decrease, the proportion between the bone conduction and the air conduction is changed in favor of the bone conduction (negative Rinné in the experimental animal).

4. There is an increase of the tensor reflex due to bone conduction after middle ear lesions are produced in the animal. From the increase of the tensor reflex it is interpreted that the bone conducted sound produces a greater irritation in the inner ear after the middle ear lesion is produced than before.

5. Observations are made on patients with increased Schwabach during noise and under almost absolute noiseless conditions. Although the increase of the bone conduction is reduced in the hearing test room there is still some increase left, which cannot be explained by any masking effect.

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ACUTE SUPPURATIVE DISEASE OF THE PETROUS PYRAMID. REPORT OF A CASE WITH A NEW OPERATIVE APPROACH.*

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DR. SIDNEY W. GROSS, New York.

The interest in acute suppurative processes of the petrous pyramid in recent years has followed the work of Eagleton, Kopetzky and others, who have pointed out certain fundamental guides in regard to diagnosis and treatment. There are numerous references in the otological literature concerning the clinical aspects of suppurative disease of the petrous pyramid, so that the syndrome is now well known to otologists. However, the management of this condition has by no means been standardized and there are differences of opinion regarding the time for surgical interference and the type of operation to be employed. With this in mind, the following case, with a description of an operative approach to the petrous apex, is recorded:

The patient was a white male, age 7 years, who was admitted to the Mt. Sinai Hospital, Cleveland, on May 24, 1934, because of attacks of pain in the left side of the face and upper jaw. At the age of 2 years he had had a bilateral mastoidectomy from which he recovered promptly without complications. He remained in good health up to about May 1, 1934, when he developed an acute otitis media (bilateral). He was in the care of the family physician until May 8, 1934, when both ear drums were incised. The child continued to have pain and a slight elevation of temperature, the old mastoid scars became red and tender. Under ethyl chloride, both scars were incised and pus obtained. The pain and fever persisted and the child was admitted to the hospital for secondary mastoidectomies on May 12, 1934. Both mastoids were quite cellular and contained pus. The patient improved rapidly and was allowed to return home on May 19, 1934, still having a very slight elevation of temperature (about 0.5°). He had been home only

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a few days when he began to complain of severe pain in the left side of the face which came on early in the afternoon and lasted for two or three hours. The temperature continued slightly elevated, and there was a purulent discharge from both mastoid wounds. On readmission to the hospital (May 24, 1934), the patient was listless and apathetic. Both ears were discharging. There was no stiff neck or Kernig. The margins of the left optic disc were indistinct, and the retinal veins engorged. There was no nystagmus; both corneal reflexes were active and sensation of the face normal. His

Fig. 1. Microphotograph of tissue removed at operation showing organizing and subacute osteomyelitis; X150.

temperature was as high as 102° F. and the white count varied from 10,000 to 18,000 per cmm. X-rays of the petrous pyramid were negative. After a few days in the hospital the right knee jerk and ankle jerk were found to be increased, and a Babinski was present on the right. His mastoid wounds continued to drain, though he was entirely free of pain. On June 3, 1934, at about 2:30 A. M., the patient awoke and complained of a severe headache. He vomited several times and his temperature was found to be 104° F. At 4:50 A. M. he had a convulsion which involved the entire right side, including the face. The eyes were turned to the right. After the seizure, the patient was deeply comatose, and he had a right

hemiparesis. By 8:00 A. M. the patient began to rouse, and the hemiparesis cleared up. He complained of pain in the left side of the head and face. A lumbar puncture yielded a cloudy fluid under a pressure of 350 mm. of water. The fluid contained 8,000 cells, most of which were polymorphonuclear leukocytes. On smear and culture many organisms recognized as streptococci were found. With the conviction that the portal of entry into the intracranial cavity was through the left petrous bone (because of the history of Vth nerve pain) the following procedure was planned: Re-exploration of the left mastoid wound with the hope of finding a sinus tract into the petrous tip, and failing this, the petrous tip was to be exposed through the middle cranial fossa.

Operation: Under avertin anesthesia supplemented by a small amount of ether the left mastoid wound was reopened. The dura over the mastoid, tegmen and aditus was exposed and appeared normal. The bone in this area appeared healthy and firm, and no fistula was found leading into the petrous bone. The exposure of the dura was continued until the bridge at the middle ear was fairly well thinned down, as in a radical mastoid operation; the bridge, however, was not broken through. The exposure was now far enough forward to provide adequate dependent drainage. The patient was then prepared for the approach through the middle fossa. A vertical incision was made just above the ear extending to a point midway between the vertex of the skull and the external auditory meatus. The incision was carried through the temporal fascia and muscle down to the periosteum. The temporal muscle was separated from the bone with a periosteal elevator and an opening was made in the skull with a perforator and burr. This was enlarged with a rongeur in all directions removing the bone to the floor of the middle fossa. The dura was carefully separated from the floor of the middle fossa and from the anterior and posterior surfaces of the petrous bone. With a small illuminated retractor the dura was lifted upwards, affording an excellent exposure of the petrous bone, at the very tip of which was a necrotic area (see Fig. 1). With a curette and suction, soft bone and thick pus were removed. A small rubber tissue drain was placed along the petrous bone down to the necrotic focus, emerging at the lower angle of the wound. A second drain extended from the necrotic focus out into the mastoid wound. The temporal muscle, fascia and galea

were closed in layers with fine catgut. The lower end of the wound was left open for drainage.

Postoperative Course: The patient's temperature remained above 103° F. for 24 hours when it was reduced to 102° F. The spinal fluid contained 7,400 cells and many organisms. There seemed to be some improvement during the next two days. The patient became much more alert, and the cell count of the spinal fluid was 1,800. On the fourth postoperative day the patient complained of a severe headache and the cell count in the spinal fluid had increased to 6,500. Following a transfusion and cisternal punctures there was temporary improvement for a few days, but the patient developed a generalized tremor, cervical rigidity, and expired on the twelfth postoperative day.

Postmortem examination (limited to head). Dr. A. M. Young.

On removal of the cranial vault the dura was somewhat more tense than normal; it was intact throughout. Extradurally in the region of the left petrous bone there was a thick fibrinopurulent exudate. The left petrous bone was soft, and on the anterior surface near the tip there was an operative defect about 8 mm. in diameter which contained fibrinopurulent material. The right petrous appeared normal. The ethmoids and sphenoids were clear. The brain weighed 1,230 gm.; it was edematous and the vessels were engorged. An abundant fibrinopurulent exudate covered the base of the brain and extended into the Sylvian fissures. The brain was cut after hardening in formalin. Except for slight dilatation of the ventricular system and the basilar meningitis as noted above, the brain appeared grossly normal. Microscopic examination showed the meninges markedly thickened and richly infiltrated by polymorphonuclear leukocytes. In the brain the blood vessels were everywhere dilated and engorged.

Comment: The problem of the treatment of otitic meningitis and other intracranial complications lies mainly in their prevention. This implies the early recognition of impending intracranial disease and the institution of measures to prevent further advance of the process. The line of attack must follow the path of infection into the intracranial cavity and this can usually be suspected from the history of the development

of the symptoms and a knowledge of the existing pathological changes.

In the case reported the persistence of an elevation of temperature and the leukocytosis following a mastoidectomy indicated the continuance of an infective process. The deep facial pain pointed to the petrous pyramid as the most probable location of the lesion. Deep seated homolateral facial pain, often referred to the temporal region and forward around the eye is often the first symptom of an infection of the petrous pyramid, and may exist (as in this case) without external rectus palsy (Gradenigo's syndrome). This is most probably due to a reaction of the meninges, either infective or toxic, which envelop the Gasserian ganglion. The latter is in intimate relationship with the petrous pyramid. This early evidence of localized meningeal reaction may be manifest by an increase of cells in the spinal fluid and an increase in the spinal fluid pressure. The removal of the extradural septic focus and the institution of proper drainage at this time may prevent the development of a frank bacterial meningitis.

Clinical signs of meningitis (stiff neck and Kernig's sign) may be lacking even when many cells and organisms are found in the cerebrospinal fluid. This condition prevailed in the case reported, since at the time of the first puncture 8,000 cells and many organisms were found, yet none of the usual clinical signs of meningitis were present. It is highly probable that had a spinal puncture been done earlier in the preoperative course the fluid would have yielded an increase in cells without organisms. The optimum time for operative interference is when meningeal irritation exists without an actual bacterial meningitis. The removal of a septic focus at this time and the establishment of drainage may ward off its occurrence. In the case reported, although a bacterial meningitis existed at the time of operation, the removal of diseased bone and drainage of the septic focus was followed by a decrease in the number of cells in the spinal fluid and temporary clinical improvement.

The approach to the petrous pyramid described proved to afford a satisfactory exposure and adequate drainage. The lesson to be learned from the case reported is the importance of doing a lumbar puncture early where an intracranial complication is suspected following middle ear disease. When a

needle of small calibre is used and only enough fluid removed for the required examinations the procedure is practically without danger. To delay a lumbar puncture until signs of a frank meningitis develop is to lose valuable time during which an overwhelming invasion of the meninges may occur.

10515 Carnegie Avenue, Cleveland.

115 East 61st Street, New York.

THE SOCIETY OF PLASTIC AND RECONSTRUCTIVE SURGERY.

The Annual Meeting of the Society of Plastic and Reconstructive Surgery will be held at the Hotel Statler, Detroit, Mich., Oct. 18 and 19, 1935. Members of the medical profession are invited to attend.

OTITIC MENINGITIS — PSEUDO BRAIN ABSCESS.*

DR. MAX RABBINER, Brooklyn.

The diagnostic acumen of the otolaryngologist is tested when confronted with an intracranial complication following mastoidectomy or nasal sinus surgery. The common complications are extradural abscess, sinus phlebitis and meningitis. In the ordinary case of brain abscess which gives us typical signs and symptoms, the diagnosis and location of the abscess is comparatively simple. On the other hand, with atypical signs and symptoms, the solution is much more difficult.

In 1924 Adson was the first to give a complete description and analysis of three cases simulating brain abscess. To these he applied the term pseudo brain abscess. The signs and symptoms were similar to those of brain abscess, but on exploration of two of these patients, no abscess was found and both eventually recovered. The third patient was not operated on and also recovered. He found that these cases give findings similar to a brain abscess and that the condition is cured spontaneously.

Cairns in his differential diagnosis of brain abscess mentions among other conditions purulent pachymeningitis and arachnoiditis (serous meningitis) as often giving signs and symptoms simulating this condition. He cited several such cases and stated that in serous meningitis following acute and chronic mastoiditis that this condition may more often give the picture of a cerebellar abscess than a temporosphenoidal. He asserts that the main clinical feature is often extreme papilloedema of a very great degree while headache and other general symptoms may be so slight that the condition is not recognized until sight is seriously impaired. He reported one such case following mastoiditis.

The case that I am reporting to you may well come under the heading of otogenic leptomeningitis with pseudo brain abscess as described by Nielsen and Courville. They described

*Read before the New York Academy of Medicine, Section on Otolaryngology, Feb. 20, 1935.

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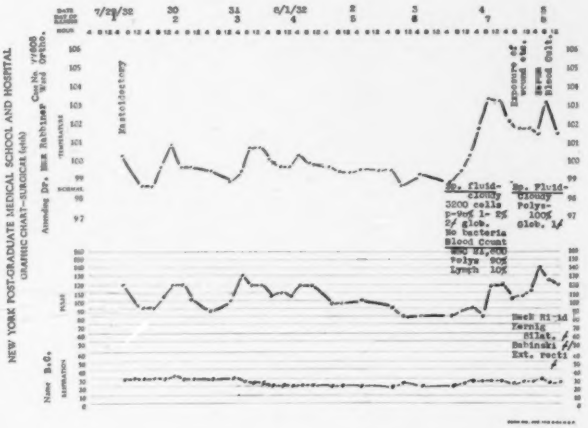
one case in which the patient showed signs of a brain abscess but on autopsy revealed a septic basilar meningitis, but no abscess in the cerebellum or cerebrum.

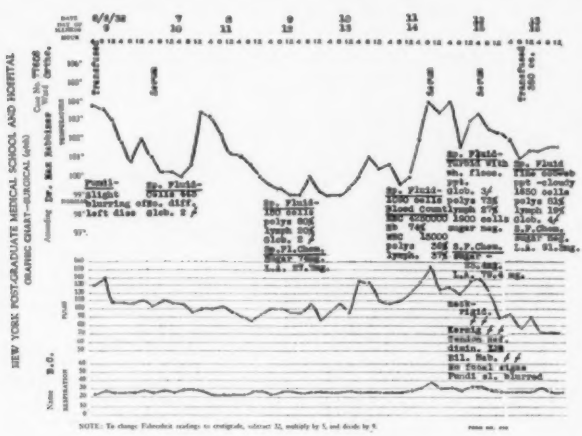
C. P. Symonds hypothecates that in the course of the formation of every brain abscess there is a presuppurative stage and if arrested at this point, it becomes resolved without the formation of pus and accounts for the signs of a cerebral abscess which are present at one time and disappear without the evacuation of pus. He reported three such cases. One who was explored twice, but on both occasions no pus was found and eventually recovered. This patient following a mastoidectomy developed headache, drowsiness, swelling of both optic


NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL
Mastoidectomy
Exposure of sag. sinus
Bp. Fluid- cloudy 3200 cells p-90% l- 2% 2% glob. No bacteria
Bp. Fluid- cloudy Polys- 100% Glob. 1+
Blood Count WBC 21,000 Polys 90% Lymph 10%
Back Rigid Kernig Bilat. Babinski +/+ Ext. recti

discs and alteration of reflexes on the left side of the body. He was operated on for right temporal lobe abscess. No abscess was found, the symptoms persisted and patient was explored 10 days later and again no pus was found, but the boy subsequently recovered. The second patient was admitted for left-sided otitis, headache and drowsiness. He showed definite aphasia and had a right homonymous hemianopia. He refused operation and also recovered. The third patient had a mastoidectomy and later developed signs of a cerebral abscess. He was operated on for right temporal lobe abscess. No abscess was found, the symptoms continued, but later he began to improve and finally recovered.

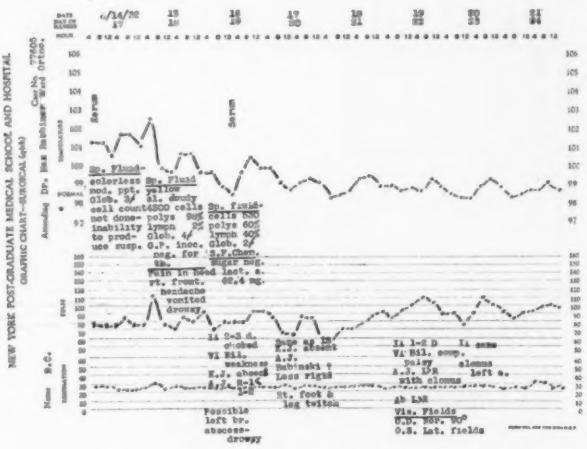
Cases of a kindred type have been described by Borries, Voss, Oppenheim and others.

My patient, B. C., boy, age 8 years, was admitted to the New York Postgraduate Hospital on July 29, 1932. Eight weeks prior to admission he was slightly ill with a low grade fever, mild red rash noticeable at night and almost disappearing in the morning. About five weeks after the appearance of the rash he developed a left otitis media purulenta for which the drum membrane was incised. During the following three weeks there was a moderate amount of purulent discharge. During the last week there was occasional vomiting which


NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL
GRAPHIC CHART—SURGICAL (gen)
Transfused
Sp. Fluid-
Sp. Fluid-
Sp. Fluid-
Sp. Fluid-
Sp. Fluid-
Sp. Fluid
Sp. Fluid-
Sp. Fluid-
Sp. Fluid-
Sp. Fluid-
Sp. Fluid-

and on palms of hands and also between toes and on soles of feet. Reflexes: Negative.

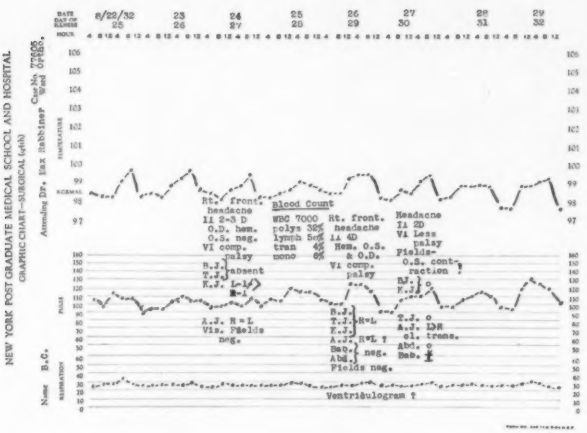
Boy was operated on day of admission, a simple mastoidectomy was performed, pus was found in mastoid cavity, structure was of pneumodiploic type. Sinus plate was found necrotic, lateral sinus exposed and found not to be involved. During the first week postoperative, the temperature dropped and took the usual course except that patient vomited his milk of magnesia on the fifth and sixth day. On the evening of Aug. 4 the temperature suddenly rose to 103.6°; he complained of severe headache and vomited repeatedly. Spinal


NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL
GRAPHIC CHART—SURGICAL (ward)
Serum
Sp. Fluid—colorless mod. ppt. Globs. 2/ cell count 4800 cells not doms- polys 80% inability lymph 20% to prod- Glob. 4/ uce susp. C.F. incr. Glob. 2/ neg. for Sugar neg.
Sp. Fluid yellow Sl. cloudy
Sp. fluid— Cells 7200 polys 60% lymph 40% Glob. 2/ C.F.Chem. Sugar neg. Cult. neg.
Pain in head rt. front. headache vomited drowsy
60.4 mg.
Possible left br. abscess— drowsy
Kernig ++
K.J. absent
A.J. Babinski + Less rigid
Rt. foot & leg twitch
Wi Bil. weakness
K.J. absent
A.J. Babinski +
Li 2-3 d. clubbed
Li 1-2 D
Wi Bil. comp. palsy
Li ataxia
A.J. lost
with clonus
Left a.
sh LM
Vis. Fields
O.D. Ner. Op.
O.S. Lat. fields

tap gave evidence of a cloudy fluid under pressure, cell count, 3200 cells with polys., 90 per cent, and lymphocytes, 10 per cent; globulin, 2+; smear, negative for organisms. He had some rigidity of the neck, slight weakness of the external recti muscles, Brudzinski positive, K.J.s normal with bilateral Babinski and Kernig positive. On Aug. 5 the mastoid wound was reopened for further exploration, dural plate over middle fossa and cerebellum was removed and no pus was found; the dura was not incised. The culture of the mastoid showed streptococcus hemolyticus. To date no organism was isolated from the culture of the spinal fluid. Unable to obtain anti-

streptococcus serum from the Board of Health since no organism was isolated from the spinal fluid, we decided to administer antimeningococcus serum intraspinally. The patient was given two injections of 20 cc. within the next three days and on Aug. 9 his temperature dropped to 100°, his meningeal signs disappeared, the cell count fell to 150, polys., 80 per cent, and lymphocytes to 20 per cent. All cultures of both blood and spinal fluid have been negative. Urine repeatedly negative.

The progress of the patient was as follows (see temperature chart):

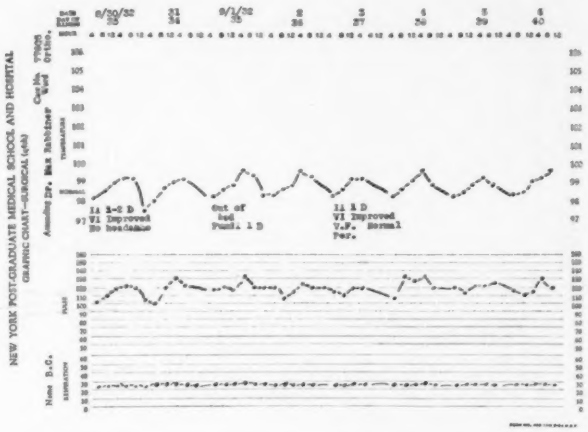


Aug. 12: Patient had a severe reaction, temperature rose to 104°, vomited and complained of severe headache. *Findings:* Fundi: Discs slightly blurred. Other cranial nerves negative. Marked neck rigidity and positive Kernig. Tendon reflexes uniformly diminished but obtained, left greater than right. Bilateral equivocal Babinski. No focal signs. Spinal fluid: Turbid with white flocculent precipitate, globulin, 3+; cells, 1900; polys., 73 per cent; lymphocytes, 27 per cent; sugar, 23.4 mg., and lactic acid, 79.4 mg. Blood count, R.B.C., 4,250,000; Hb., 72 per cent; W.B.C., 15,000; polys., 68 per cent; lymphocytes, 32 per cent.

Aug. 13: Temperature, 101°, transfusion, 350 cc.; spinal fluid: Cells 1650; polys., 81 per cent; lymphocytes, 19 per cent; globulin, 4+; sugar, negative; lactic acid, 91.3 mg.

Aug. 15: Temperature, 100° to 101°, severe pain in head, right frontal headache and drowsy. Guinea pig inoculation for tubercle bacilli negative. Spinal fluid: Yellow, slightly cloudy; cells, 4500; polys., 98 per cent; lymphocytes, 2 per cent and globulin, 4+.

Aug. 16: Patient dozing, but alert and irritable, lies hyperflexed, painful to straighten extremities. Neurological exami-

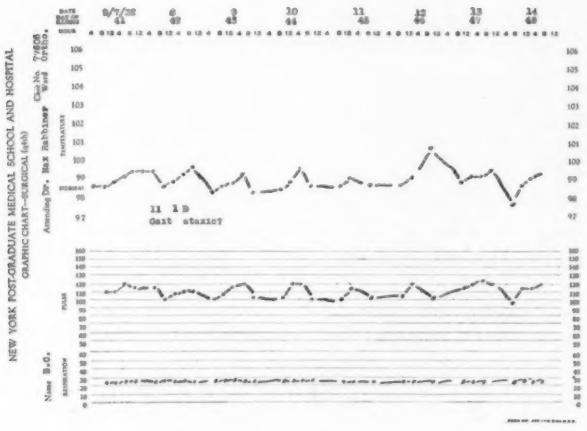

NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL
GRAPHIC CHART—SURGICAL (old)
Out of bed Fund. 1 D
11 1 D VI Improved V.F. Normal Per.

nation: Bilateral choking 2-3 diopters of both discs, veins tortuous and engorged, several small early hemorrhages, visual fields negative by rough test; VIth nerve bilateral weakness complete. Reflexes: A.J.s right less than left. Sensation good. No cerebellar signs. Impression brain abscess above tentorium on left. At this point decided to stop draining spinal canal and withheld further administration of serum. Spinal fluid: Cells, 530; polys., 60 per cent; lymphocytes, 40 per cent; globulin, 2+; sugar, none; lactic acid, 62.4 mg. Temperature receded to 100°. General condition improved. Decided to observe.

Aug. 17: Temperature below 100°, discs the same, less rigid, no headache. Nurse noticed occasional twitching of right foot and leg.

Aug. 19: Cranial nerves, bilateral choking 1-2 diopters; VIth nerve bilateral complete palsy. Reflexes: A.J. left greater than right with left ankle clonus. Abdominals left greater than right. Visual fields: Perimetry O.D. normal, O.S. contraction of lateral field? Appears generally better.

Aug. 20: Seems brighter. Fundi same. Left ankle clonus; temperature down.



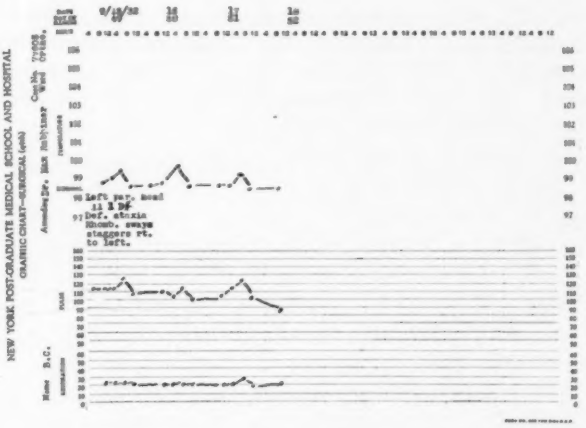
Aug. 24: General condition better, but complains of right frontal headache. Fundi, 2-3 diopters, two small early hemorrhages in right fundus. Slight hyperesthesia of left face. Corneal reflexes active and equal. Complete bilateral palsy of both external recti. Reflexes: B.J. and T.J. absent. K.J. left equals 1+ and right 1. A.J.s right equals left, no clonus. Visual fields negative.

Aug. 26: Feels better, temperature down, eating and sleeping well, complains of right frontal headache, intermittent and recurrent. Examination active and co-operative, neck easily flexed and lies on back. Cranial nerves: Fundi, 4

diopters choking bilateral, definite hemorrhages in both eyes; IIIrd and IVth no nystagmus, react to light and accommodation; VIth nerve: Right and left palsy complete. Reflexes B.J., T.J. and A.J. left equals right. Blood count, W.B.C., 7000; polys., 32 per cent; lymphocytes, 58 per cent; transitionals, 4 per cent; monocytes, 6 per cent.

Aug. 27: Choking down to 2 diopters. Headache still persists. Left visual field questionable. A.J. left greater than right with transient clonus.

Aug. 29: Improved, out of bed. Fundi show no advance in choking.



Aug. 31: Improved, up in chair. Fundi 1-2 diopters. No new hemorrhage; VIth nerve, less weakness.

Sept. 2: Daily improvement, up and about and eating well. Fundi: O.D. disc is pink and congested, but of better appearance. Disc margin still indistinct. No pallor to suggest atrophy. Bilateral 1 diopter of choking; VIth nerve still some bilateral weakness, but much less than before. O.D. 20/20, O.S. 20/20.

Sept. 8: Up and about, eating well, no subjective diplopia. Fundi margins still indistinct about 1 diopter of choking. Gait is slightly ataxic (bedridden six weeks).

Sept. 12: Visual fields normal. General improvement.

Sept. 15: Complains of headache in left parietal area. Has been noticeably unsteady on his feet with tendency to stagger, frequently reaching for wall or furniture. Temperature up one day. Neurological examination: Fundi, no changes, 1+ diopter of measurable edema; IIIrd, IVth and VIth nerves no nystagmus, eye movements normal. Very definite ataxia which daily becomes more difficult to explain on basis of general weakness. Rhomberg: Does not fall but sways definitely. Cannot stand on either foot alone. Gait ataxic, base wide, staggers jerkily to right and left. Finger to finger, finger to nose, heel to shin satisfactorily done. Impression: Possible cerebellar abscess although signs are only suggestive.

Sept. 17: Active and playing about. Does not appear sick. Fundi outlines still not clear, 1+ diopter of choking. Visual fields negative; IIIrd, IVth, VIth and VIIth cranial nerves negative. Rhomberg: Some swaying but does not fall. Patient discharged from hospital.

Oct. 7 *(Follow Up Notes):* Since his discharge patient has been examined neurologically once a week. There are no complaints. Daily temperature normal. Urine has been negative at all times. Neurological examination negative except that fundi still shows 1 diopter of choking but without advancing. Still some unsteadiness in gait. The gait is peculiar. Walks like with stiff joints (slightly bent forward, clamping feet, etc.).

April 1, 1933: Very active, no complaints. Back to school. Fundi outlines hazy, no measurable edema. Visual fields normal. Patient seen by me several months ago is in excellent health and carrying on all the functions of a normal boy.

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358 New York Avenue.

ETIOLOGY OF RETROBULBAR NEURITIS.*†

DR. JOHN H. DUNNINGTON, New York.

Retrobulbar neuritis as pointed out by Benedict is a confusing term which leads to an inaccurate localization of the lesion somewhere between the globe and optic chiasm, while, as a matter of fact, the lesion causing the anopsia often lies in the chiasm or posterior to it. To the ophthalmologist the term "retrobulbar neuritis" conveys a certain clinical picture, the salient features of which are: Diminution of vision; a central scotoma and a normal fundus. Weill has aptly described the condition as "a disease in which neither the patient nor the physician sees anything." The classical symptoms are frequently accompanied by pain on motion of the eye ball and retrobulbar tenderness on pressure. It is either acute or chronic in its development and may involve one or both eyes. In the acute form there is a rapid loss of vision which may even go on to complete blindness, while in the chronic cases there is a very gradual loss of central vision. The disease is characterized by its marked variability in severity and in duration. Many cases recover spontaneously while others in spite of all treatment have some permanent impairment of vision.

With this variable clinical picture before us we must approach a discussion of its etiology with an open mind. As Wilmer has reminded us, the optic nerve is but a prolongation of the white matter of the brain with a cellular structure similar to that of the brain, hence, its reaction in disease will be like that of the central nervous system. This structural difference accounts for its great susceptibility to toxins and poisons that do not affect other histological elements. The literature is full of references to disease in which retrobulbar neuritis has been found, but time will not permit a complete survey of all of them; however, it will not be amiss to call your attention to a few diseases other than sinusitis in which this condition has been described.

*Read before the New York Academy of Medicine, Section on Otolaryngology, Dec. 19, 1934.

†From the Department of Ophthalmology, Columbia, University.

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Many clinical poisons such as lead, arsenic and thallium affect the optic nerves. Owing to the recent widespread use of thallium in depilatory creams, several cases of retrobulbar neuritis due to this cause have been encountered. These and many other remote etiological possibilities can best be eliminated by a careful history and a thorough physical examination by an internist.

Interruption of the function of the optic nerve by pressure from tumors in the region of the optic chiasm is well known when it presents the typical bitemporal hemianopsia, yet how often does one consider this possibility when confronted with a unilateral retrobulbar neuritis.

The following case report is illustrative of the importance of this sign:

D. E. B., Aet. 46. *Complaint:* Blurring of vision of the left eye of a few weeks' duration.

History: General health good. Had been myopic for years and had been refracted by me at regular intervals for preceding 10 years, always with normal vision in both eyes. Upon careful questioning a history of disturbed sleep with annoying dreams for past few months was obtained.

Eye Examination: Vision R.E. 20/15 with myopic astigmatism corrected. Vision L.E. 20/200 unimproved by lenses. Fundus examination was negative and no pathology was discovered to account for reduced vision. Paracentral scotoma was detected and slight constriction of upper temporal field in the left eye.

Comment: This patient was referred to Dr. Carl M. Sautter for nose and throat examination with negative results. General examination was negative. X-ray of sella turcica by Dr. G. S. Dixon was reported as follows: "There is an enormous amount of destruction in the sella turcica, indicating the presence of a large hypophyseal tumor. The floor of the sella is practically gone. His frontals are rather small considering the stature of the patient and the size of his head. A median cell is present. They are rather cloudy but the frontal cortex is quite thick, which probably accounts for the cloudiness. The ethmoids are broad and clear. There is some thickening in the antra. The nasal septum is deviated slightly to the right. The

sphenoidal sinus region has apparently been encroached upon by the pressure from the growth in the region of the sella."

He was referred to Doctor Harvey Cushing, who removed a large pituitary adenoma, and this eye when last examined Dec. 28, 1933, was 20/15, no scotomata were present and the field of vision was normal.

Suspicion of the real nature of the trouble was first gained by the scotoma plotting and the X-ray findings corroborated the diagnosis. A previous X-ray taken to exclude sinusitis had failed to disclose the extensive pathology in the sella turcica. With this case in mind I believe it is proper to insist upon a complete X-ray of the skull on all of these cases before proceeding with a radical intranasal operation. Negative X-ray findings of course do not preclude the possibility of a suprasellar lesion. This type of tumor, as has been stressed by Cushing, affects the vision first and may produce findings identical with those just described with the exception that there is no destruction of the sella turcica.

Careful visual field tests are essential for the early detection of those intracranial lesions. In the earliest stages very little change is seen in the peripheral fields and, as Walker has pointed out, it is necessary to do the tests carefully and repeatedly to elicit them. Any case with a persistent central or paracentral scotoma should have the peripheral fields thoroughly investigated. Cushing is strong in his condemnation of the ophthalmologists who have caused so many of his patients to have needless intranasal operations merely because they have failed to detect defects in the peripheral fields. While it is the ophthalmologist who must make the final decision it is entirely within the province of the rhinologist to insist upon repeated visual field tests before operating upon those patients with questionable intranasal pathology. In other words, in these cases we must first exclude the possibility of an expanding intracranial lesion.

There are many who think that multiple sclerosis is the chief cause of retrobular neuritis. Benedict in his analysis of 225 of these cases at the Mayo Clinic considered 155 of them to be due to multiple sclerosis. Several European writers, notably Weill, Scheerer, and Adie, have also stressed the frequency of retrobulbar neuritis in the initial stages of multiple sclerosis.

Adie found acute retrobulbar neuritis to be the initial symptom in 38 per cent of his cases of multiple sclerosis. This same author has called our attention to the long interval that may elapse between the attack of retrobulbar neuritis and the appearance of other signs of multiple sclerosis. He found the average time to be eight years and the longest 24 years. Holden, in 1922, also stressed the importance of multiple sclerosis as an etiological factor in retrobulbar neuritis and says "we now have learned that if the other common causes of central scotoma can be eliminated diminution of abdominal reflexes warrants us in diagnosing multiple sclerosis, even if no other symptoms are present." Retrobulbar neuritis due to multiple sclerosis is usually acute in its onset and often affects both eyes although only one may be involved. The maximum disturbance of vision is usually reached in a few days and recovery may take place in an equal time. Relapses are very common.

Interest in infection of the nasal sinuses as a cause for optic neuritis was stimulated by the anatomical studies of Onodi, Loeb and Schaeffer, and furthered by Sluder's description of hyperplastic ethmoiditis and sphenoiditis. The intimate anatomic relationship between the optic nerve and the accessory sinuses is apparent to all who have seen the beautiful specimens presented tonight. The variations in these anatomic relationships may be an important factor in determining whether or not the optic nerve may be attacked. Von Der Hoeve, one of the earliest enthusiasts, called attention to the following ways in which a diseased sinus can affect the optic nerve: *1.* By direct spreading of the inflammation; *2.* By pressure by the walls of a dilated sinus as we see in the cases of mucocele where every nerve in the neighborhood may become atrophic by pressure; *3.* The deleterious influence may be exercised by toxins, edema, congestion, etc. The possibility of the infection directly spreading into the optic nerve has been doubted by many and the strongest argument against its occurrence is the relative infrequency of optic nerve involvement in purulent sinusitis. If involvement of the optic nerve results from a direct extension of the infective process it would seem logical to expect to find it most commonly in the severe cases of sinusitis. Such is not the case and it is generally agreed that optic neuritis is a rare complication of purulent sinusitis.

Herzog in an attempt to establish the possibility of involvement of the optic nerve by direct extension described the intimate relationship between the dural sheath of the nerve and the cortical spaces of the bone separating it from the ethmoid and sphenoid cells. After a study of 12 cadavers he came to the conclusion that the character of the bone was the important factor in determining the likelihood of optic nerve involvement. Those cases presenting a thick bone were relatively immune to optic neuritis while those with a thin cancellous bone were most likely to develop it. These studies along with those of others do offer evidence that optic neuritis can arise by direct extension, but we are still unable to state the frequency of its occurrence. More definite information is needed on the pathology of the tissue removed. Insistence upon a histological examination of all tissue removed would seem to be the first step towards the solution of this problem.

Pressure from a mucocele of the ethmoids or sphenoids can affect the optic nerve and cases of this type are recorded, yet they are rare. It would appear as if corroborative evidence of the presence of the mucocele should be disclosed by an X-ray examination of the sinuses.

Following Sluder's description of hyperplastic disease of the sinuses, great attention was directed to the sinuses as a focus of infection and many cases of optic neuritis were subjected to radical intranasal operations. Some brilliant cures were effected while in other identical cases no result was obtained. The role played by hyperplastic sinusitis in the production of optic neuritis is still a moot question. A review of the literature is most confusing, but we do find as the years have passed a tempering of the enthusiasm for this form of treatment. White, one of the earliest proponents of radical intranasal operations, later modified his views and came to the conclusion that many more of them were due to infections of the tonsils or teeth. Benedict in his analysis of 225 of these cases found sinusitis the causative factor in only one instance and states that "even in the presence of dehiscences in the bony walls in either acute or chronic disease of the ethmoid and sphenoid cells lying near the optic nerve, the incidence of visual disturbances in patients seen in the Mayo Clinic is negligible." He furthermore says, "except when it is possible definitely to establish a diagnosis of suppurative disease of the sinuses I

think that advising an operation on the sinuses is unwarranted in any case of retrobulbar neuritis."

Against such conservatism we still find many authors enthusiastically endorsing exploration of the sinuses in obscure cases of optic neuritis, while others, notably Gifford, adopt a more rational middle ground position. This author urges careful discrimination, but says, "with our present information and methods of diagnosis there will still be a number of cases in which exploratory operation on the sinuses is indicated."

Judging from my own experience rhinogenic retrobulbar neuritis is rare. Those cases that at first appear to be of sinusitic origin later turn out to be due to some other cause. The rhinologist can be of great help in the solution of this difficult etiological problem by demanding a thorough investigation before exploring the sinuses. He should no longer be a surgical tool in the hands of the ophthalmologist. He must remember that he is the surgeon and that the patient will hold him responsible for an unsuccessful operation. He should be familiar with the other causes of retrobulbar neuritis and adopt every precaution to avoid unnecessary operation upon the sinuses. To recapitulate he should know that:

1. Retrobulbar neuritis is a disease characterized by a marked tendency towards a spontaneous recovery. With this thought in mind he should adopt a watchful waiting policy and first try conservative measures.

2. Retrobulbar neuritis is frequently the first manifestation of an intracranial neoplasm. Repeated visual field tests and careful X-ray examination of the entire skull may be necessary to establish such a diagnosis, so he should insist upon these examinations before opening the sinuses.

3. Retrobulbar neuritis is often the initial sign of multiple sclerosis, and sometimes it precedes the other symptoms by many years. Therefore, a thorough neurological examination should be done on every case before resorting to intranasal surgery.

4. A careful history along with a complete physical examination may be of great help and should constitute a part of the preliminary examination.

If the rhinologist will insist upon this information before exploring the sinuses he will have been of inestimable value in the solution of the etiology of retrobulbar neuritis.

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30 West 59th Street.

THE PRESENT STATUS OF THE SUBMUCOUS AND TURBINATE OPERATION.*

DR. WESTLEY M. HUNT, New York.

The topic of this paper is the present status of the septum and turbinate operation — in other words, the submucous resection and turbinectomy.

The submucous operation and turbinectomy have grown up together, each being done with the idea of accomplishing the same results.

The submucous resection originated some 30 years ago and has not yet reached its peak in usefulness, while the turbinectomy reached its peak in popularity about 25 years ago, and since that time has been on the decline.

No two persons agree exactly when or how to do a submucous, and the turbinate has been slaughtered with wholesale ruthlessness, or its preservation held almost sacred.

It may seem to us that we have not improved in technique or results during the period of our own experiences but, in fact, there has been a definite improvement in technique and results from year to year.

I cannot go back 30 years to the beginning of the submucous, but I can go back 20 years. This is a period which still means present to most of us and was in the beginning a period of condemnation of the removal of turbinate tissue and the rise of the submucous resection of Watson's and Gleason's. Twenty years ago we were still observing the result of the Ashe operation with its uncertain results, also the results of Bosworth's saw operation, and later the spoke shave operation with the denuded and crusty areas of the nasal structure.

In order to evaluate the progress made and the change in ideas over these 20 years, I have looked over THE LARYNGOSCOPE from 1914-1930. The results are interesting, particularly because it gives a view of the work of the men in this

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section over this period. It shows their interest in this subject and their contributions to the advancement in technique and better results.

In 1914, Dr. Stauffer described his modern submucous resection suggesting the substitution of novocain for cocain for injection, using cocain for application to the mucous membrane. He felt that children should not have a submucous until 15 years of age, but questioned the advisability of waiting if a sinus or ear complication could be avoided by operation. He felt that the possibility of faulty nasal development should be forgotten when there was a complete blocking of one or both of the nares. He cautioned against operation on cases of pulmonary tuberculosis. He felt that an outstanding cause of a failure to relieve nasal conditions by a submucous operation was the failure to remove a compensating turbinate. He advocated leaving packing for two days and claimed for his submucous resection a relief of headache, clearer thinking, better sleeping, better sense of smell, improved hearing, relief of recurrent rhinitis and improvement of the voice.

At the same time Dr. Tiding, of Chicago, was suggesting the submucous rearrangement of the deviated septum without its removal.

During 1914, a plea was made for preserving at least the major portion of the middle turbinate and carbon dioxide snow was suggested for shrinking the turbinate. It was said that after this application there was no scar as is seen after the actual cautery.

In 1915, Dr. Robert Buckley with the aid of Dr. Thomas Harris, Dr. Abraham and Dr. Samuel McCullagh, as discussors, described a repair operation for septa perforated at the time of the submucous operation.

In 1916 and 1917, we found Dr. Lee Hurd and Dr. Wesley Carter correcting deformities caused by the submucous resection. At the same time Dr. Sluder described a new method of application of the galvanocautery to the turbinate. The cautery had been used since 1854, with varying results. Dr. Sluder advocated a series of cauterizing lines around and along the turbinate rather than one lineal cauterization.

Thus does the interest in the turbinate die down, there being no reference in THE LARYNGOSCOPE, except in 1923, some work

on the pneumatization of the turbinate by Dr. H. L. Baum and in 1924, a plea for the submucous resection of the turbinate by Dr. Spielberg, and two articles by Dr. L. M. Harris in 1925 and 1927, advocating the clamp and cautery method of removing redundant turbinate tissue.

The septum operation continued to gain in popularity. In 1918, Dr. J. William Wright pleaded for conservation in nasal surgery and suggested that all cases of deviated septum have a hypertrophied turbinate. He warned against the indiscriminate removal and cauterization of it. He said he could find no iron clad rule for removal of the septum other than common sense, but did quote cases in which a submucous resection had failed to relieve the symptoms which later were relieved by injection of supraorbital branch of the Vth nerve, allergy arrested by vaccine, elimination of a pelvic condition, and the removal of a third molar. He brought to our attention the necessity of more careful handling of the septum problem.

In 1919, Dr. Henry Hall Forbes and Dr. Wesley Carter again corrected nasal deformities due to the submucous operation. This same year Dr. John Cavanaugh told us of his "septum shave" which did a submucous spoke shave operation of spur and deformity, preserving the septum, eliminating perforation, flopping membrane, and deformity. It could be used at any age.

Then we skip along from 1919 to 1923, when we find Dr. Carter and Dr. J. W. Lewis doing plastic operations for deformities due to the submucous resections.

In 1918, Dr. John Hoffman, of Canton, Ohio, gave his indications and contraindications for the septum operation.

Indicated: 1. For the drainage and ventilation of the nasal accessory sinuses; *2.* for the relief of nasal stenosis.

Contraindicated in: 1. Children before puberty; *2.* active luetics; *3.* tuberculosis and diabetes; *4.* neurotics; *5.* in perceptive deafness; *6.* bilateral atrophic condition of the nose; *7.* lessened visual acuity unless one is sure it is due to the septum; *8.* irregular septum with no symptoms.

In 1922, Dr. Creighton Barker brought out a new septum chisel.

In 1924, Dr. Mervin C. Meyerson brought out a new septal elevator, and others corrected nasal deformities due to the submucous operation.

In 1925, Dr. McFarden presented a new modification of Adams' forceps and Dr. Marvin Jones a new septal mucous membrane elevator.

In 1927 and 1927, more nasal perforation and more deformities were corrected.

In 1927, Dr. Atkinson, of Texas, described a new L-shaped incision in which he rolled up the flap and placed a pledget of cotton between the periosteum and cartilage of the other side to keep the mucous membrane out of the way of injury after the cartilaginous septum has been cut through.

In 1928 and 1929, Dr. Frances White made a real contribution to nasal surgery, suggesting a modified submucous operation on the child's septum, readjusting the deviated part by the removal of a corresponding amount of cartilage.

Dr. White had no deformity and in 100 cases quite proved its usefulness.

Dr. Carter also wrote on this subject, and both Dr. White and Dr. Carter warned against any tugging instruments in septum surgery such as the swivel knife. Dr. Carter also advocated the use of gold wire splints rather than packing, getting away from the two days' packing of a few years ago.

In 1930, more repair work was done.

In 1933, Dr. Wallace Morrison suggested the sheep's head for practice of the submucous resection.

During these latter years the interest in the turbinate has been quite lacking until in 1927, diathermy began to be used. With the introduction of electrocoagulation Dr. Lee Hurd did much to change the technique of turbinate treatment. The introduction of his bipolar electrode made this method bloodless and effected a reduction of the hypertrophy of the mucosa without injury to the bone and with a minimum amount of destruction to the mucosa itself.

So we come to 1934, with the submucous a well established and satisfactory operation for the removal of nasal obstruc-

tion. We use a technique which has been changed but little since the operation was devised. There is less inclination to long and extensive packing of the nose after operation. Novocain has by some supplanted cocain for anesthesia. The allergic, the red, and the white membrane, have been brought to our attention. The reflex manifestation due to the so-called "trigger area syndrome" has had its influence on septum surgery.

We have seen in our own group progress made in diagnosis, instruments suggested and technique developed. You will recall about every two years one or two methods have been devised for correcting the perforation and deformities following submucous resection. This does not indicate necessarily bad technique, but it does cause one to be more cautious in performing the submucous operation. If the real obstruction has been removed the urge to produce an absolutely straight septum may not be quite so great.

There was a time when a submucous was done by the rhinologist before sending a suitable case for a nasal plastic operation. The tendency now is to do the submucous later, after the desired cosmetic effect has been attained, or correcting it at the time of the plastic operation.

At the present time the submucous operation is a constructive operation well understood, easily performed and of exacting technique. It should be performed for either nasal stenosis or to facilitate sinus drainage.

The tendency today is to promise too much for the submucous—we cannot expect to cure deafness, neurosis, atrophy, luetic, allergic, acid or alkaline mucous membranes; nor can there be accomplished by a submucous ample breathing space in a narrow nose with a thick septum. In the latter cases an extensive resection of the septum is suggested. Most of our failures are due to a lack of common and mechanical sense in our selection of cases.

Today, given definite indication, we feel fairly safe in doing a modified submucous on small children without expecting a later deformity. Today we all still use different instruments and technique to accomplish the same result, and appreciate even better, that all septa are crooked and that normal functioning nasal mucous membrane is something to be preserved.

Today, the turbinectomy is not in such good favor. In fact perhaps we have acquired too much conservatism. There are still cystic and enlarged turbinates which must be removed. The recognition of the allergic membrane has somewhat changed our thought in recent years.

There is still too much sacrifice of the turbinate in making antra windows. Many noses drip in an embarrassing way when an acute cold develops after an intranasal opening of the antrum. The electrocoagulation of the soft tissue of the turbinate by the insertion of the needle into tissue is our latest step forward. This has succeeded the actual cautery in most cases.

Each year sees fewer noses mutilated by turbinectomy, which should be confined to actual bony hypertrophy or in making room for a further surgical procedure.

33 East 68th Street.

POLYPI OF THE NASAL SEPTUM. REPORT OF TWO CASES.

DR. ROLAND D. RUSSELL, Chicago.

Polypi of the nasal septum are rare in the writer's experience. In over 75,000 examinations made in the past four years by the writer and his associates they have been observed only twice, and the literature on the subject is not voluminous. In a hurried review of the literature of the past 10 years only one article bearing on the subject could be identified by the title and indexing, *viz:* a review of the German literature and a report of 13 cases of his own by Wilhelm Schryer. This author found opinions as to whether these lesions were inflammatory in nature or belonged to the neoplasms pretty well divided. They were variously classed as granulomata, myxomata, fibromyxomata, fibromata, telangiectatic polypi and hemangiomata. The location of the lesions in the cases reviewed and reported was anterior. The etiology was attributed to nasal sinus infection, rhinitis sicca anterior, irritations and traumata. Because in this author's cases, the inflammatory reaction was chiefly in the superficial portions, while the new blood vessel formations were deeper, and also on account of the cavernous nature of the vessels, he was inclined to class the lesions as neoplastic.

Case 1: Born in Sweden, age 42 years; came March 23, 1934, complaining of difficulty in breathing through the nose. The patient had had symptoms of nasal discharge and obstruction for over 20 years. He stated that in 1929 he had had an intranasal operation, which he thought was a submucous resection, with but little benefit.

Examination failed to show any evidence of a submucous resection having been performed. On the contrary, the septum was markedly deviated to the left. Pus was seen in the right naris, and both nares were practically occluded by masses of polypi. Both maxillary sinuses failed to transilluminate; the right frontal transilluminated well, and the left poorly. X-ray

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examination showed evidence of a bilateral pansinusitis. The tonsils were large, and the pillars thickened. The pharyngeal mucosa was injected.

April 6: Scarred, densely adherent tonsils were removed.

April 18: A submucous resection and polypectomy were done. The septum was markedly deviated to the left with a long vomerine ridge on the left side surmounted in the mid-portion by a spur which was in contact with the inferior turbinate. On the right side there was a corresponding concavity. On both sides posteriorly there were several polypi, some with a narrow pedicle and some with a broader base attached to the septum in the region of the upper portion of the vomer and lower portion of the perpendicular plate of the ethmoid. Laterally on both sides there were polypi springing from the ethmoid areas. There was no evidence of a previous submucous resection having been performed, but the middle turbinates were practically absent on both sides. An extensive submucous resection was done, and the polypi with narrow pedicles were removed from the septum, but those with a broader attachment were left for removal at a later date for fear of perforating the septal flaps. The lateral polypi were also removed.

Histological examination of one of the septal polypi revealed findings similar to those of typical lateral nasal polyp. The polyp was covered with columnar epithelium which was ciliated in places. There were numerous mucous glands dipping into the underlying connective tissue stroma. The blood vessels near the surface were dilated; those in the deeper stroma were of smaller caliber with thicker walls. There was considerable leukocytic infiltration beneath the epithelial layer and around the vessels nearer the surface; the deeper portion of the connective tissue stroma showed less leukocytic infiltration but was more edematous than the more superficial portion. The leukocytic infiltration consisted of polymorphonuclear and large and small mononuclear cells, the mononuclears predominating.

May 18: A bilateral Caldwell-Luc operation was performed at which both maxillary sinuses were found to contain pus. The mucosa showed marked polypoid changes with small abscess and cyst formations. Smears from the sinuses showed

chiefly mononuclear leukocytes, and cultures revealed the presence of the staphylococcus albus.

June 11: The remaining septal polypi were removed, also two polypi from the anterior ethmoid area on the right side and two from the posterior ethmoid area on the left side.

The patient was last seen June 14, at which time he had no further evidence of polypi and no nasal discharge.

Case 2: A white male, age 39 years; came, June 8, 1934, complaining of diminishing vision of several years' duration.

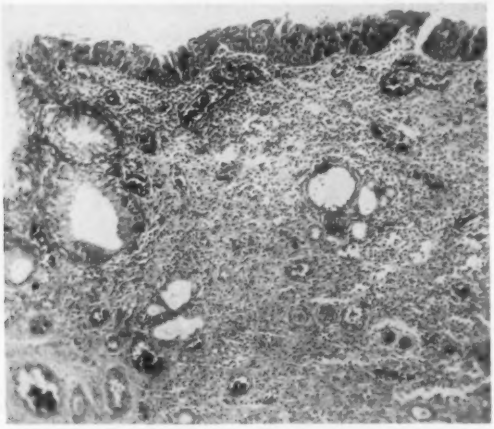

Fig. 1. Case 1, inflammatory polyp.

He had had a tonsillectomy several years previously. For the past three years he had had difficulty in breathing through the nose, and since his nose had been injured one year ago he had had a continuous "cold."

The general physical and neurological examination revealed no significant findings. The vision in each eye was 20/100, and could not be improved by refraction. The ocular media and fundi were negative. The visual fields were normal. There were multiple polypoid masses in both nares. The left maxillary sinus failed to transilluminate, and the sinus films showed an abnormal density in the left maxillary sinus. The septum

was quite irregularly deviated. The pharyngeal mucosa was injected.

Feb. 2: The nasal polypi were removed, and a bilateral ethmoid exenteration carried out.

Feb. 23: A left Caldwell-Luc operation was done. The sinus was found to be practically filled with hyperplastic tissue. Cultures showed the presence of the hemolytic streptococcus and a small Gram negative bacillus.

There was no marked improvement in the patient's condi-

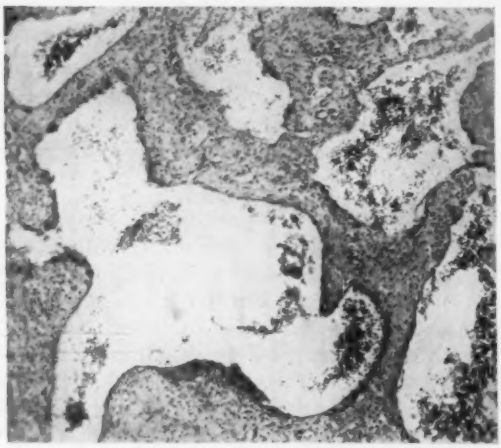

Fig. 2. Case 2, hemangioma.

tion following these procedures. The nasal musoca remained swollen, and he suffered low grade headaches.

Shortly after the second operation, a small granulation appeared in Kesselbach's area, and this gradually increased in size until it measured about 1 cm. The surface was irregular and the color reddish.

April 10: The lesion of the septum was excised, and the electric cautery applied to the base.

The tissue was reported by the pathologist as a hemangioma. The sections showed the mass to be covered by strati-

fied squamous epithelium. The underlying tissue consisted largely of blood vessels with fibrous connective tissue with, here and there, sheets and strands of endothelial cells. There was some leukocytic infiltration. The vessels varied greatly in thickness. There were numerous relatively large spaces. Some of the vessel walls were ill-defined, and there were hemorrhagic areas.

May 2: A submucous resection was performed, still without striking benefit to the patient. The nasal mucosa continued to be swollen and edematous.

June 29: Nasal polypi were removed from both ethmoid areas, and on July 20 a left middle and inferior turbinectomy was performed.

The patient gradually improved. The swelling of the mucosa gradually lessened, and his vision, when last seen, Aug. 31, was O.D., 20/50; O.S., 20/40. The presbyopic correction was No. 2J. There was at the time no evidence of a recurrence of the septal lesion.

Comment: Two types of nasal polypi are shown. One is no different in histological structure from the usual lateral nasal polyp, but the other shows a decided angiomatous structure though macroscopically the lesion has the appearance of a granuloma. Both lesions arose in association with severe paranasal sinus infection. In the first case, the polypi were in all probability of long duration. In the second case, the septal lesion arose while the patient was under close observation, and was, therefore, seen in its very incipiency. This is definitely a benign neoplasm which might never have arisen, had it not been for the stimulating action of the paranasal infection with its irritating action on an area prone to blood vessel proliferation.

55 East Washington Street.

AN OBSERVATION ON THE TREATMENT OF OSTEOMYELITIS OF THE SKULL, WITH REPORT OF A CASE.*

DR. CLARENCE H. SMITH, New York.

My purpose in presenting this subject is to call to your attention an agent which apparently may be of service in combating the formidable disease, acute spreading osteomyelitis of the skull. One is apt to give all the credit to the operative procedures in a successful surgical case and to ignore the other therapeutic measures.

Osteomyelitis is rarer in the flat bones than it is in the long bones. Wilenski[1] estimates the ratio as one to six and that the skull bones make about 3 per cent of the flat bone group.

Osteomyelitis is usually seen in the young, because the diploe is most marked then.

The causes are trauma, sinusitis and hematogenous infection.

Furstenberg[2] calls attention to two methods of infection, by continuity of tissue and by hematogenous metastasis. In the first, the diploe is directly infected from the diseased sinus. In the blood-borne variety he thinks that the infection travels from without to the vessels in the dura mater. From the dura, retrograde thrombophlebitis carries the infection to the diploe between the tables of the skull. The infection often spreads wildly through the osseous structures. When the outer table gives way we have swelling and scalp abscesses. When the inner table is destroyed we have extradural abscess formation. The dura withstands the infection for a time, but diffuse meningitis or a brain abscess commonly follows.

Mosher[3] brings out a valuable point in estimating the limit of the infection of the medulla by the extent of the edema.

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He says, "Edema means infection of the medulla of the bone and of the periosteum and they run a parallel course." He thinks the X-ray will not show that this bone is infected until seven to 10 days after the edema, because the X-ray shows only necrotic bone. He has demonstrated that the medulla is infected for an inch or two beyond the necrotic areas. He advocates removal of the bone from the limit of the edema.

McKenzie[4] was among the first to advocate wide removal of the bone, beginning in the normal bone well beyond the periphery of the diseased bone, and working from healthy to infected tissue, removing this as radically as if it were a malignant growth.

In osteomyelitis of the frontal bone Mosher[3] advises starting the skin incision beyond the limits of the edema, at the hairline, and carrying it down the center of the forehead to the root of the nose. He makes a lateral incision slightly above the eyebrow for its full length. If both frontal sinuses are infected a similar incision is made over the opposite eyebrow. Both flaps are turned upward and outward and the whole forehead can then be inspected. He advises beginning the removal of the bone beyond the edema and carrying it downward from normal to diseased bone. Furstenberg[2] removes the bone from the diseased area outward into healthy bone.

Furstenberg[2] states that the cranial bone defect is replaced. He reports that in eight patients on whom he operated there had been perfect obliteration of the surgical defects through the medium of regenerated bone. He believes that the dura plays a part in this ossification, aiding the periosteum. He says that granulation tissue arises from the dura, assumes an embryonic character and is transformed into osseous tissue. He stresses the influence of heat, light and massage. He particularly recommends the infrared lamp, as an aid to speedy regeneration of bone.

The usual organism found in osteomyelitis of the skull is the staphylococcus aureus.

MacNeal and Frisbee[5] in writing in 1932 on the bacteriophage as a therapeutic agent in staphylococcus bacteremia say: "Our experience previous to 1929 with patients giving two successive positive staphylococcus blood cultures has been

extremely uniform. All had died." They then go on to report seven recoveries in a series of 15 patients suffering from staphylococcus bacteremia, where the bacteriophage had been used. They consider that the bacteriophage affects the bacterial cells so that they become more susceptible to the cells and fluids of the defending host, such as the phagocytic leukocytes.

I will now report the case of a patient who had an extensive hematogenous cranial bone osteomyelitis with bacteremia, who was apparently aided to recovery by the administration of a specific bacteriophage.

Armando P., age 37 years, entered Morrisania City Hospital Sept. 7, 1934, complaining of pain and swelling around his left eye. These symptoms were of five days' duration. He appeared to be acutely ill. His temperature was 104° F. He had had fever for five days. Three weeks previously he had a furuncle on the tip of his nose; this after a couple of days had drained spontaneously.

Examination: There was a slight proptosis of the left eye. The eyelids and the conjunctiva of this eye were edematous. His lungs showed signs of a commencing pneumonia. A neurological consultant noted aphasia and stated "Patient may have a metastatic focus in left hemisphere."

Course: During the next five days patches of pneumonia appeared in both lungs. The medical consultant's opinion was that this was metastatic in origin. There was a sustained high temperature. The patient was toxic and delirious.

On Sept. 12 a blood culture was positive for the staphylococcus aureus. This was again positive on Sept. 15, on Oct. 11, and Oct. 15.

The swelling in the periorbital tissue of the left eye increased in size and it was incised on Sept. 14, pus was evacuated, and a drain was inserted.

Edema appeared over the left frontotemporal region on Sept. 12. The possibility of another abscess in the soft tissues like that around the left eye seemed plausible. The thought that there might be an underlying osteomyelitis was entertained, but as the patient was so extremely sick from his pneu-

monia, we temporized with local applications until Sept. 26. On that day, his pneumonia having resolved, an incision over the left frontotemporal region was made. Pus was obtained. A drain was inserted.

On Sept. 28 a neurological consultant reported slight lower facial weakness on the right side, motor aphasia, bilateral Kernig reactions and other localizing signs which suggested to him a brain abscess in the frontal lobe. Exploration was advised against temporarily.

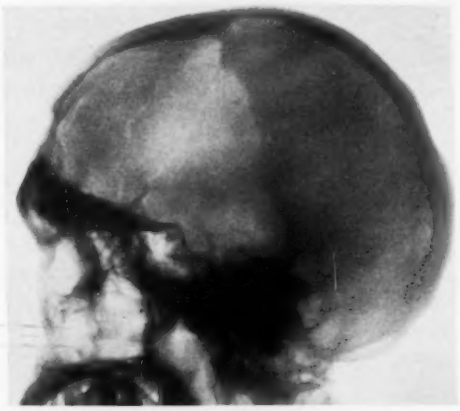
Showing area of bone removed.

First Operation: On Oct. 1 under avertin anesthesia the left half of the frontal bone was exposed and an area of osteomyelitic bone was removed exposing an extradural abscess. It was felt that all of the diseased bone was not removed, but the patient's poor condition prevented more being done.

Some days of struggle followed. The patient showed marked mental depression, drowsiness, headache, disorientation, and deepening aphasia. It was determined to make

another effort to eradicate the diseased bone, so on Oct. 9 he had his second operation.

Second Operation: The former wound was reopened and more diseased bone was removed from the left half of the frontal bone, from the left parietal bone and from the squamous portion of the left temporal bone. The frontal lobe was explored with negative results. The temporosphenoidal lobe was aspirated, with negative results. During the operation it was noted that veins traversing the dura were thrombosed and full of pus. More extradural abscesses were found.



Showing area of bone removed.

Cultures taken from the extradural abscesses, the periorbital abscess, the temporofrontal scalp abscess, and from the blood, all grew staphylococcus aureus.

The patient had been given a commercial stock bacteriophage during his illness up to this time. After his second operation he appeared to be desperately ill; no one on the staff expected that he would live. On Oct. 11 a stock undiluted asparagin bacteriophage from the laboratory of the New York Post-Graduate Hospital was given under the direction of Dr. Ward J. MacNeal. A total amount of 70.5 cc. was administered intravenously in six hours. The day after this medica-

tion was given the alteration in the patient's condition was extreme. Instead of being utterly irresponsive and semi-comatose, he was now bright and smiling, and when examined in his native tongue even the aphasia was considerably less noticeable. All blood cultures taken thereafter were negative.

He was given 10 cc. of the stock bacteriophage twice daily intravenously until Oct. 15, when he was given in divided doses 53.5 cc. of a specific bacteriophage, enough to have him show signs of shock reaction.

Patient on recovery.

He was given the bacteriophage intravenously in smaller dosage until Nov. 8.

Besides the intravenous administration of the bacteriophage a broth preparation of the bacteriophage was used to bathe the wounds at each dressing.

As the neurological symptoms still persisted, aphasia, right facial paralysis, and other localizing symptoms suggestive of a middle fossa abscess, it was decided to essay a third operation.

Third Operation: On Oct. 19 under avertin anesthesia the temporoparietal region was exposed. The temporosphenoidal

lobe was again aspirated and at a depth of approximately two inches, an abscess was entered. About 1 drachm of thick pus was obtained. A Mosher drain was inserted in the abscess cavity and was sewn *in situ*. A culture from the pus grew the staphylococcus aureus.

More of the left parietal bone and more of the squamous portion of the left temporal bone were found to be diseased and were removed. The operation had to be discontinued before healthy bone was reached on account of the patient's poor condition from loss of blood.

After an interval of five days, on Oct. 24, the patient had his fourth operation.

Fourth Operation: More of the frontal bone and more of the left parietal bone were found diseased and were removed. Two extradural abscesses were uncovered. The operation was discontinued on account of the patient's weakened pulse due to loss of blood.

Fifth Operation: One week later, on Nov. 1, the wounds were carefully revised and the margins of the surgical defect were found to be apparently of healthy bone, excepting in one region, the external angular process of the frontal bone, from which some diseased bone was removed. The brain abscess was draining very little and the Mosher drain was replaced by a rubber tube. An attempt at a plastic repair was also made.

After the fifth operation the asparagin bacteriophage was injected into the brain abscess cavity at each dressing. The discharge diminished rapidly and the drain was finally removed on Nov. 12.

Sinuses from staphylococcal infection of the scalp after operation were treated by injecting the bacteriophage into them. The result was immediate; in 24 hours the sinuses were entirely healed.

On Nov. 30 the *Sixth Operation* revealed no more diseased bone and more plastic work was done on his forehead.

On Jan. 2, 1935, the *Seventh Operation* was performed. Some plastic repair on the scars was done.

On Jan. 16 the aphasia and the right facial paralysis, which had almost disappeared, returned. This was followed by headache, vomiting and mental depression. These signs and symptoms were ascribed to a refilling of the brain abscess. A tube was reinserted in the abscess cavity on Jan. 26. Pus was obtained. The cavity was treated at intervals of three or four days by suction and by injections of bacteriophage. On Feb. 26 the last drain was removed from the brain and the wound rapidly healed completely.

The patient left the hospital on March 3 in good condition. The neurologists at that time could find no abnormal signs.

He will have to wear an aluminum skullcap for a time outdoors, until his bony defect regenerates.

CASE SUMMARY.

Infection traveled from the furuncle on the nose through the angular vein to the periorbital tissues, causing an abscess.

The lungs were early infected by metastases.

At the time of admission to the hospital the temporosphenoidal lobe was already infected.

A scalp abscess in the frontotemporal region was next seen.

Osteomyelitis of the frontal bone, of the left parietal bone, and of the left temporal bone was the next happening. Five operations were required to eradicate this.

An abscess was located in the temporosphenoidal lobe. This was drained and it apparently healed. Refilling occurred and the abscess had to be drained again.

Complete recovery apparently.

In conclusion I would emphasize the value of bacteriophage therapy in this case in conjunction with the surgical measures.

The staphylococcus bacteremia was evidenced by four positive blood cultures. After the first intravenous administration of the bacteriophage the blood thereafter showed negative cultures. Coincident with this therapeutic measure there was a marked improvement in the patient's condition.

In addition, the bacteriophage, when used locally in the scalp abscesses, in the bone wounds and in the brain abscess

seemed to be a great aid in arresting the suppuration. This is particularly important in the bone wounds as the secretions readily infect the healthy bone.

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THE CRIBRIFORM PLATE (OLFACTORY GROOVE) MENINGIOMAS AND THEIR EARLY DIAGNOSIS.*

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The subject of the early diagnosis of meningeal growths which are derived from and attached to the dura which covers the cribriform plate of the ethmoid, should be of particular interest to the specialist in diseases of the nose and throat. From their very inception these growths involve the olfactory nerves and may disturb the sense of smell, and many of them must affect the nasociliary nerve in its intracranial course and thereby alter the sensibility of part of the nasal passages. Sooner or later the optic nerves or chiasm are subjected to pressure with a resulting diminution of vision. As disturbances of this character may be caused by disease of the accessory sinuses of the nose, the patients are often suspected of having sinus disease and are seen by the rhinologist. The latter should at once think of the possibility that the disturbances are due to a small meningeal growth of the cribriform plate, and should be aware of the methods by which the early diagnosis of growths in that situation can be made. All of this is only additional evidence that the roads traveled by the workers in different specialties constantly cross each other.

The technical difficulties encountered by the surgeon during the removal of the meningiomas attached to the basilar dura underneath the frontal lobes, and indeed of meningeal growths wherever situated, are directly proportional to the size and vascularity of the neoplasm. From the surgical as well as the clinical standpoint, therefore, it is important that the diagnosis is made and the operation performed before the growth has become large.

The ideal has been reached in growths in two situations; those attached to the dura of the tuberculum sellae and those attached to the dura of the mesial part of the sphenoid ridge.

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Cushing and Eisenhardt[1] were the first to recognize and to describe the combination of disturbances characteristic of tuberculum sellae growths. From the syndrome of bilateral primary optic atrophy, bitemporal defects in the visual field and slight atrophy of the sella turcica it is possible to make the early diagnosis of growths in that situation. Recently Dyke and I[2] have described a combination of disturbances produced by small growths attached to the mesial part of one sphenoid ridge. This syndrome consists of unilateral optic atrophy, a defect in the visual field of the same eye, slight atrophic changes in the sella turcica and a characteristic alteration in the outline of the interpeduncular cistern after encephalography. From this symptom complex it is possible to recognize and to remove growths attached to the mesial part of one sphenoid ridge when they are very small, 1 to 10 gm.

With these two exceptions, the meningiomas underneath the frontal lobes, whether derived from the dura of the orbital roof, the upper surface of the lesser wing of the sphenoid, the outer part of the sphenoid ridge, or the cribriform plate of the ethmoid, have rarely been recognized and operated upon until they have reached a considerable size. In many instances the clinical diagnosis was not made and a large unsuspected neoplasm was found at the postmortem examination.

Meningeal growths attached to the dura of the cribriform plate or olfactory groove are not at all rare, but prior to the publication of Cushing's first paper the so-called olfactory groove tumors were rarely recognized as such. For the most part the literature contains isolated case reports (Siewers[3], Vincent, Roger and Giraud[4], Hall[5], Blackburn and Hough[6], etc.).* Many of the reports were of unsuspected autopsy findings in patients who, on account of mental symptoms, had been confined in hospitals for the insane.

In 1927, Cushing[7] collected 12 cases from the literature and added four of his own. In two of his patients the clinical diagnosis of olfactory groove tumor was made and the growth was successfully removed. Cushing was the first to recognize that a meningeal growth in this situation was a distinct clinical entity to which he gave the name olfactory groove meningioma.

*Some of these cases are referred to in Cushing's paper.[7]

In 1928, in a paper on electrosurgery as an aid to the removal of intracranial tumors[8] the same author stated that he had operated upon 10 patients with meningiomas attached to the dura of the olfactory groove.

In 1929, Boestrom and Spatz[9] reported four cases. In three of these a previously unsuspected tumor was found at autopsy while in the fourth patient, the diagnosis was made before

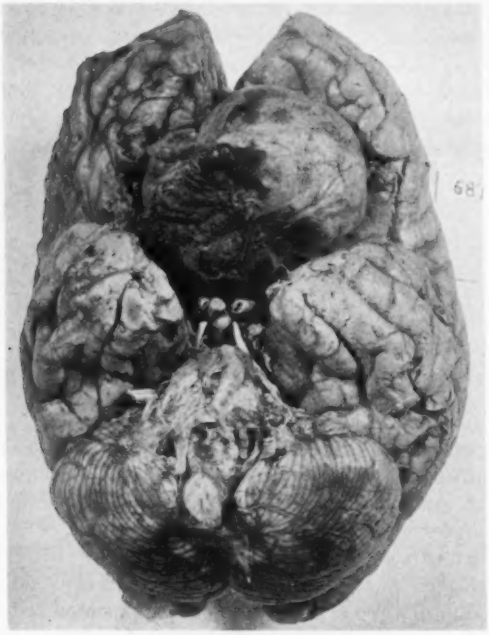

Fig. 1. Brain and tumor in the case of a large cribriform plate meningioma.

death. In the same year Rupp[10] published a paper on tumors in the pituitary fossa or in the neighborhood of it, which contained reports of the cases previously described by Boestrom and Spatz.

In all of these publications the illustrations show lesions which in situation and gross appearance closely resemble one another. The photographic reproductions of the tumors at

autopsy or removed at the surgical intervention are almost uniformly of growths of large size (see Fig. 1). An illustration of a small growth unexpectedly encountered at a postmortem examination (see Fig. 2) was given by Virchow[11] in his classical work, "Die Krankhaften Geschwülste," and

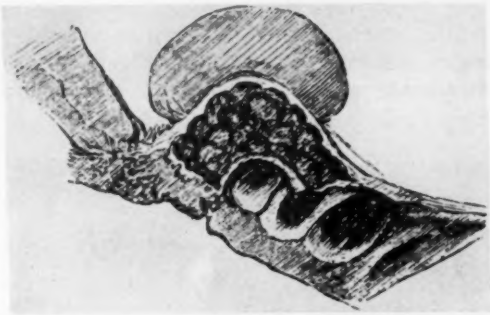

Fig. 2. Small cribriform plate meningioma found postmorten (Virchow).

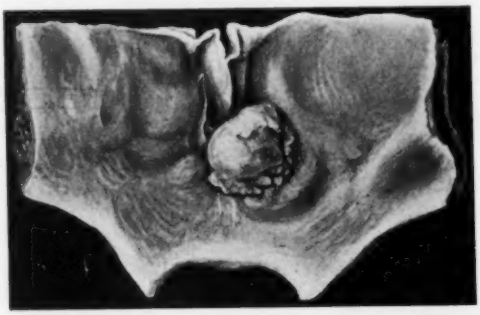

Fig. 3. A small cribriform plate meningioma (Museum of the Royal College of Surgeons—Cushing[7]).

another (see Fig. 3) by Cushing[7] which he found in the collection of the Museum of the Royal College of Surgeons in London.

Apparently it has been generally accepted that most of these growths can be clinically recognized only when they have reached a large size. The symptoms usually described are

those that one might expect from a large subfrontal growth, a history of long duration, advanced impairment of vision, loss of smell, marked mental changes, and various other neurological disturbances. In many instances, on account of its large size, the growth could not be completely removed. If the diagnosis had been made when the growth was small, perhaps not much larger than that shown in Figs. 2 and 3, operative removal would have been a relatively simple procedure. It is, therefore, of considerable surgical importance to recognize meningeal tumors in this situation when they are of small size, and this is the end toward which we must strive.

THE FREQUENCY OF THE MENINGIOMAS IN GENERAL AND OF THE CRIBRIFORM PLATE TUMORS IN PARTICULAR.

Up to Jan. 1, 1935, our verified brain tumor series consisted of 1,204 cases divided as follows:

TABLE I.

THE CLASSIFICATION OF 1,204 PATHOLOGICALLY VERIFIED BRAIN TUMORS.

Gliomas		673=56%
Unclassified	161	
Verified by cyst fluid alone	126	
Astrocytoma	130	
Fibrillary	76	
Protoplasmic	23	
Mixed	31	
Oligodendroglioma	13	
Spongioblastoma polare	12	
Pinealoma	2	
Ependymoma	8	
Medulloblastoma	71	
Medulloepithelioma	2	
Astroblastoma	6	
Tuberosclerosis	5	
Glioblastoma multiforme	137	=11%
Meningeal fibroblastomas		195=16%
Perineurial fibroblastoma of acoustic nerve		109= 9%
Pituitary adenomas and adenocarcinomas		58
Bucconeural pouch tumors		25
Dermoids and epidermoids		12
Granulomas		11
Blood vessel tumors		22
Metastatic—invasive from bones of skull		51
Sarcomas (primary in dura or brain)		17
Papillomas of choroid plexus		8
Miscellaneous		23
		1204

TABLE II.

THE SITUATION AND RELATIVE FREQUENCY. OF 195 MENINGIOMAS.

Parasagittal (attached to sinus or falx)	48=24.6%
Over the cerebral convexities (not attached to longitudinal sinus or falx)	53=27.1%
Temporal (attached to dura of base)	24=12.3%
Occipital (attached to tentorium or lateral sinus)	5
Sphenoid ridge or cribriform plate	37=19.0%
Mesial part of sphenoid ridge	4
Tuberculum sellae	11= 5.5%
Subtentorial	10= 5.1%
Multiple	3
	195

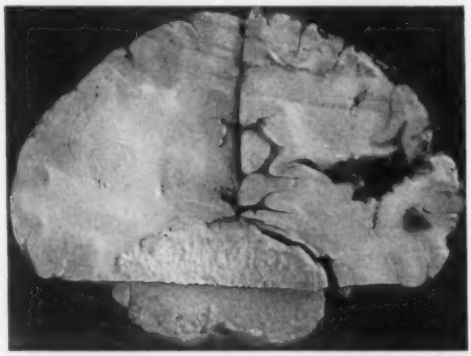

Fig. 4. Cross-section of the brain showing the bilateral extension of a cribriform plate meningioma.

The tables show that in our series of pathologically verified tumors of the brain the meningeal fibroblastomas (meningiomas) occurred in 16 per cent, and that in 19 per cent the growths were attached to the dura which covers the cribriform plate, olfactory groove, orbital roof, or adjacent part of the lesser wing of the sphenoid bone. In 15 cases the growth was derived from the dura of the cribriform plate, or in addition, from the adjacent dura over the orbital roof and the neoplasm extended up to or across the midline. These 15 cases form the basis for this paper.

SITUATION AND BLOOD SUPPLY.

Growths in this situation may be derived from the dura of one olfactory groove but, more often, the attachment is to the

dura of the entire cribriform plate. Therefore, on account of the dural attachment it is more correct to use the term cribriform plate than olfactory groove meningioma. The cribriform plate meningiomas are often midline growths which occupy space on both sides of the anterior cranial fossa (see Fig. 4), but the extension may be mainly to one side underneath one frontal lobe. If the dural origin is mostly on one side of the

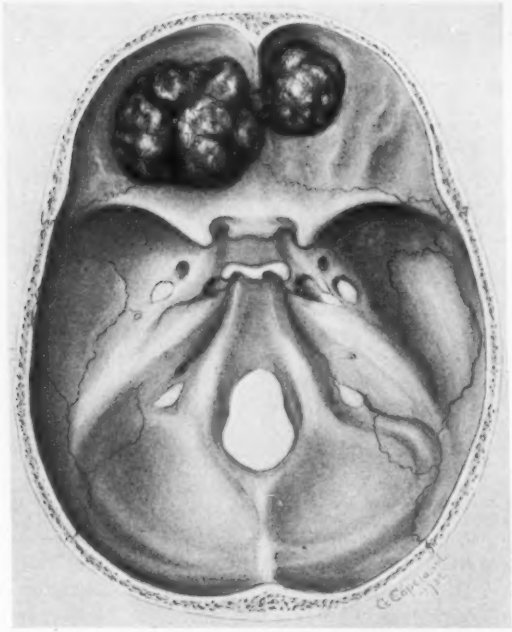

Fig. 5. Size and position of a cribriform plate meningioma originating mostly on the right side of the cribriform plate. The larger portion of the tumor mass lay to the left (diagrammatic).

midline, the neoplasm may at first be predominantly unilateral, but it soon extends a lesser or greater distance to the other side underneath the anterior part of the falx cerebri. In one of our patients the attachment of the growth was mainly on the right side, but the larger tumor mass not attached to dura lay on the opposite side (see Fig. 5). In some instances the attachment includes some of the adjacent dura of the orbital

roof, so that it may be impossible to determine whether the primary site of origin was the dura of the orbital roof or that of the cribriform plate.

From their very beginning the growths involve and make pressure upon the olfactory nerve and bulb of one or both sides. Soon the tumor makes a bed for itself in one or in both frontal lobes. Later the optic nerves, chiasm and pituitary body are affected by pressure. The subarachnoid cisterns in their vicinity, the cisterna chiasmatis, interpeduncularis and lamina terminalis are pressed upon, and after encephalography air does not fill the cisterns, or their outlines are altered (see Fig. 6). Finally, the growth makes a large nest for itself in the

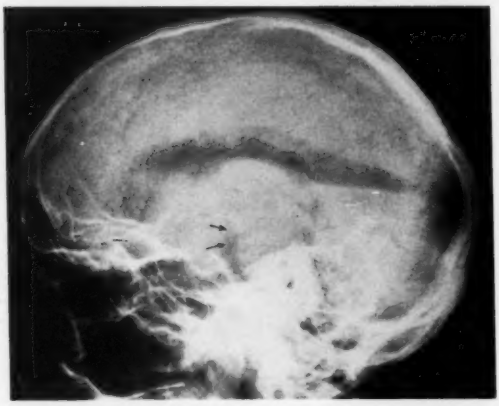

Fig. 6. Deformity of the interpeduncular cistern in a case of cribriform plate meningioma (arrows point to the concave border which is abnormal).

frontal lobes (see Fig. 7), and the anterior part of the corpus callosum is involved by direct or transmitted pressure. As a result of these mechanical changes the function of the olfactory nerve is first disturbed followed by interference with the optic nerves and chiasm, the pituitary body, and finally the frontal lobes and corpus callosum.

The blood supply of the cribriform plate meningiomas is derived from several sources: *1.* The arteries in the dural attachment are enlarged branches of the ophthalmic artery. These ethmoid vessels arise from the ophthalmic artery as it

passes along the inner wall of the orbit. The vessels enter the cranial cavity through several foramina and supply the dura over the cribriform plate. There are often two larger arteries in the dural attachment of the tumor, one near the base of the crista galli, the other near the posterior part of the cribriform plate (see Fig. 8). *2.* Meningeal branches, derived from the internal carotid artery in its intracranial portion enter the under surface of the growth. They are of considerable surgical importance, for they may be injured when the neoplasm is raised out of its bed. *3.* If the neoplasm is of large size,

Fig. 7. Large cavity in both frontal lobes, the result of a large cribriform plate meningioma.

branches of the middle cerebral and anterior cerebral arteries may extend to the capsule of the growth. After the removal of a large cribriform plate meningioma the anterior cerebral artery is often exposed for some distance in the tumor bed.

THE NEUROLOGICAL DISTURBANCES IN GENERAL.

As the meningiomas attached to the dura of the cribriform plate have generally been recognized and operated upon in an advanced stage, the clinical picture that has been described was based upon the history of onset and the progress of the

symptoms, and the objective neurological disturbances found at this late period of their life history. The fact that for a long period the symptoms are vague has made it all the more difficult to describe a characteristic clinical syndrome. Sketched in gross outline, the story of an individual who has a growth in this situation is the following:

As in other tumors of the brain, headache, for which no adequate cause had been discovered, may have been complained

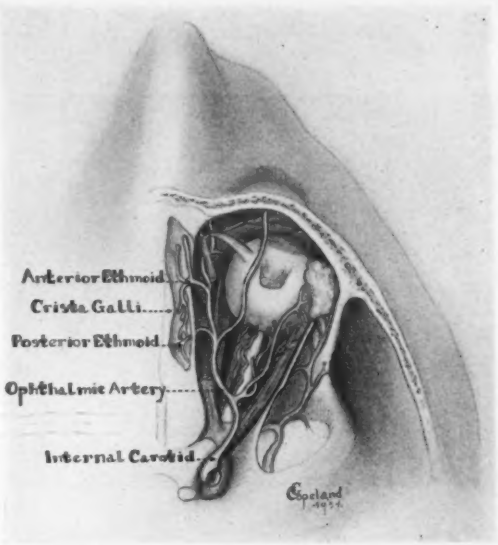

Fig. 8. The main blood vessels which supply the cribriform plate meningiomas. These are derived from the ethmoid branches of the ophthalmic artery.

of for one or more years. On the other hand, a painless course is not unusual. Then vision begins to be impaired and disturbances of the sense of smell may be noticed. The sinuses are therefore suspected and treatment for possible sinus disease instituted, usually without benefit. As the impairment of vision becomes greater, mental disturbances appear, a slight change in character, impairment of memory and of ability to concentrate, euphoria, etc. The mental changes may predominate so that the patient may be admitted into a hospital for the insane. Finally, with growths of large size, there are disturbances in

the functions of the hypophysis with evidences of pituitary insufficiency.

The patients are often seen by the neurologist and the neurosurgeon when the disease is far advanced and when there are marked mental changes. Excepting for disturbances of function of the olfactory and optic nerves the neurological examination may be entirely negative. There is often complete anosmia or loss of the ability to recognize and name odors (olfactory agnosia). Vision is greatly reduced and perimetric tests show either marked concentric contraction of the visual fields or homonymous or bitemporal hemianopsia. The fundus

Fig. 9. Cranial hyperostosis in a cribriform plate meningioma.

examination reveals advanced bilateral primary or secondary optic atrophy, or primary atrophy of one and papilloedema of the other eye, or bilateral papilloedema. In a case reported by Hall[5] there was unilateral loss of vision and of smell.

The Roentgen examination of the skull shows atrophy of the clinoid processes and floor of the sella turcica and a hyperostosis which involves the base of the skull in the anterior cranial fossa (see Figs. 9 and 10).

THE OLFACTORY DISTURBANCES IN PARTICULAR.

From their very beginning the cribriform plate meningiomas make pressure on and interfere with the functions of the

olfactory nerves and the extracerebral parts of the olfactory pathways. The reason why disturbances of smell are recog-

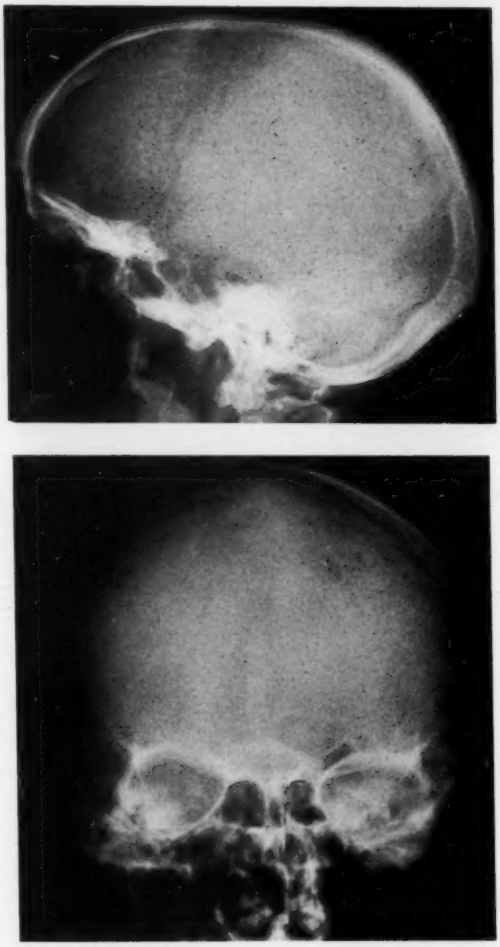

Fig. 10. Cranial hyperostosis in a cribriform plate meningioma. (A) Lateral view. (B) Anteroposterior view.

nized so late by the patient and the physician are threefold: A unilateral loss of smell is seldom appreciated and even

bilateral impairment may not be noticed. This suffices to explain the fact that history of loss of smell is obtained in so few patients who are found to have a unilateral or bilateral hyposmia, anosmia, or olfactory agnosia. For this there is, however, another explanation. In the story of an individual with marked impairment of vision who is fearful that he is becoming blind, a slight disturbance of the sense of smell may not be mentioned unless the patient is specifically cross-questioned on the subject. Undoubtedly in the past, insufficient

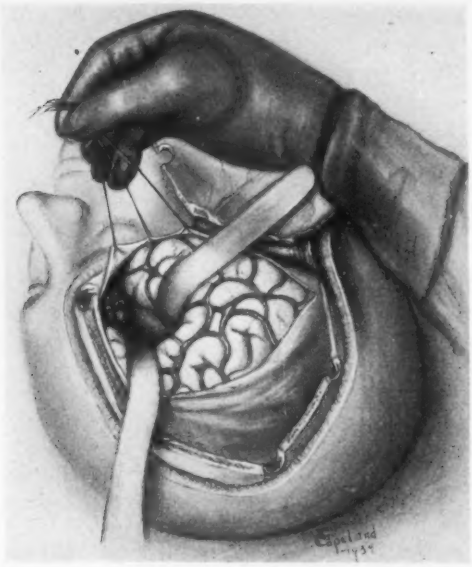

Fig. 11. An exposure of a cribriform plate meningioma approached by elevation of the frontal lobe from the side.

attention has been devoted to this part of the patient's story. Last, but by no means least important, the methods used to test the olfactory sense are gross and to a considerable extent unreliable as regards slight grades of impairment of smell. Finer tests are greatly needed. In states of increased intracranial pressure as well as in direct pressure upon the olfactory nerves there must be an interference with olfactory function which should be recognizable by appropriate and delicate tests.

Although many investigations of olfaction have been made by Zwaardemaker, Nagel, Henschen, Henning, Bornstein, Bednar and Langsfelder, Dussik and Kauders, Proetz, Parker, to mention only a few of the most important, an exact and sensitive clinical test for smell has not yet been devised. With Dr. Irwin Levy and Dr. Earl D. Brewer I have been studying the subject of odorimetry and olfactometry. We hope, in the near future, to describe a practical clinical method and to report upon a new classification of odors and odorous substances.

However, even with the crude clinical tests now used, if a more careful examination of the olfactory sense was made by the physician in every patient in whom an intracranial lesion is a *possibility*, disturbances of smell should be recognized more often. This subject is surely of great interest to the rhinologist.

In the 15 cases upon which this paper is based, a history of impairment or loss of smell was obtained in five patients. In four of them the olfactory impairment had been recognized by the patient one or several years before he came under our care. It may be that if all of the patients had been more carefully questioned regarding their sense of smell, a history of disturbances of smell might have been more often obtained. In 14 of the 15 patients, on the other hand, the *examination* showed that there was more or less marked olfactory impairment — a complete anosmia in nine, a reduction in the ability to recognize odors (hyposmia) in two, and a loss of the ability to name them (olfactory agnosia) in three patients. In some of the cases the impairment of smell was more marked on one side than on the other. In two patients there was also some disturbance of the sense of taste.

In five patients olfactory hallucinations had preceded the loss of smell. One patient stated that he smelled a camphor-like odor for many weeks before he became aware of the impairment of smell; another smelled peculiar odors which he could not name; two had recurring attacks for a year during which they smelled "something burning;" and the fifth complained of olfactory hallucinations, but could not describe them.

Eight of the 13 patients had been treated or had been operated upon for suspected sinus disease before they came under our observation. From the statements in the hospital records it was not possible to conclude whether there had been demon-

strable disease of the sinuses or whether the therapy had been tried because of the possibility that visual or olfactory disturbances or both were due to a latent sinus infection.

The facts given above demonstrate that in 14 of the 15 patients, (93 per cent) the examination showed that smell was definitely diminished or lost. In all of the cases the meningioma was of large size and clinically the patients were in an advanced stage of their disease. It is fair to assume that if a reduction in olfactory acuity had been especially looked for, it might have been discovered much more early. Perhaps it was actually found by the rhinologist before the patients came under our observation, but on account of the absence of other symptoms aside from those referable to vision, the disturbance was considered to be due to a local lesion in the nose or in one of the accessory sinuses.

THE EARLY DIAGNOSIS OF THE CRIBRIFORM PLATE MENINGIOMAS.

When a patient presents himself to the physician on account of disturbances of vision without other symptoms and is referred to the rhinologist in order to learn whether there is an affection of the nasal accessory sinuses, the possibility of a cribriform plate meningioma must always be thought of. If, in addition, there is a history of olfactory disturbances or if, at the examination, a diminution of smell is discovered, the diagnosis of cribriform plate meningioma must be seriously considered. If there is no definite lesion such as an obstruction in the nasal passages which prevents inspired air reaching the olfactory mucous membrane, an intranasal disease such as ozena, or advanced sinus disease, another cause for the anosmia must be looked for. If definite sinus disease is not found, X-ray films should be taken not only of the sinuses but of the entire skull, and a careful stereoscopic study should be made in the search for a small hyperostosis of or in the neighborhood of the cribriform plate.

If there are not any bony changes, valuable time should not be lost by prolonged local treatment of the nasal accessory sinuses, but an encephalography should be done without delay and the Roentgen films studied by an expert.

One of the main purposes of this paper is to suggest this new indication for encephalography to rhinologists and to

those who see patients with unexplained disturbances of vision and of smell. In experienced hands the procedure of encephalography is practically without danger in patients in whom there is no general increase of intracranial pressure. Small tumors attached to the dura of the cribriform plate ought to produce characteristic alterations in the outline and filling of the basal arachnoid cisterns.

It is the writer's impression that, all in all, in disease of the nasal accessory sinuses, primary optic atrophy and papilloedema and marked impairment of sight are unusual. Therefore, in every case of diminution of vision for which no adequate cause can be discovered, encephalography is indicated in order to exclude an intracranial lesion which has affected the optic nerves or chiasm by direct pressure. Finally, the combination of visual and olfactory impairment without other symptoms is always an indication for encephalography.

THE SURGICAL TREATMENT.

Little need be said concerning the technique of the exposure and removal of these growths. The unilateral transfrontal approach is made under local or local and avertin anesthesia. Formerly, as recommended by Cushing, the anterior part of the incision in the scalp was through the line of the eyebrow, but now a type of "concealed" scalp incision is used in which the base of the soft tissue flap is at the eyebrow and the periosteum bone flap has its base low in the temporal region.

Formerly it was my practice, after the bone flap had been raised, to separate the dura from the orbital plate of the frontal bone and the lesser wing of the sphenoid until the posterior edge of the latter was laid bare, and then to incise the dura along this line. For several years I have found this separation of the dura unnecessary. The dura is incised along a line parallel to the anterior edge of the opening in the bone from near the midline outwards and downwards until the Sylvian vessels and the anterior part of the temporal lobe are exposed. From the mesial end of this line of incision a second cut is made directly forward almost down to the region of the crista galli. At the mesial part of the incision a large vein is often encountered which runs from the brain to the dura. This vessel must either be avoided or it must be clipped and divided. During the past year I have found the anterior part of the

dural incision unnecessary; if the incision extends well back over the temporal lobe, the frontal lobe can be elevated without difficulty and the exposure of the chiasmal and prechiasmal region will be adequate for all necessary manipulations. To be sure, there is more than one road leading to Rome, but my preference for the approach to growths located in or near the sella turcica is by elevation of the frontal lobe from the side rather than from in front (see Fig. 11). If necessary, additional room can be obtained and the elevation of the frontal lobe made more easy by puncture of the ventricle and evacuation of cerebrospinal fluid.

The piecemeal removal of the growth by the aid of electrosurgical apparatus is now a standardized method and nothing need be said about it. After the removal of the part of the growth on the side on which the frontal lobe has been elevated, the exposure of the part on the opposite side is made more easy by division of the falx or separation of its attachment to the crista galli.

At the close of the operation the dural incision is closed by interrupted sutures.

Up to the present time, the removal of the large meningiomas in this situation has been time consuming and it has not been unusual that five or more hours were required for the entire operation. In the future, when the diagnosis will be made earlier, the exposure and removal of small growths will surely be accomplished with the expenditure of much less time and energy.

Of the 15 patients, 12 recovered and three died, a case mortality of 20 per cent. Nine were reoperated one or several times, so that not counting two-stage procedures, 24 operations were performed on the 15 patients, giving an operative mortality of 12.5 per cent. The high operative and case mortality was directly due to the fact that in the majority of the patients (14 of 15) the tumor was of large size. If, and when, the diagnosis is made early, operative fatalities should be the exception.

SUMMARY AND CONCLUSIONS.

1. The cribriform plate meningiomas occurred in 1.2 per cent of a series of 1,204 pathologically verified tumors of the

brain, and in 7.7 per cent of 195 intracranial meningeal growths.

2. Disturbances of the sense of smell were found in 93 per cent of the patients, all of whom had large growths.

3. The site of origin of the growths and their situation is such as to interfere with the functions of the olfactory nerve from the beginning.

4. When more delicate and reliable tests for olfaction have been devised, impairment of smell should be found in the cribriform plate meningiomas when they are small in size.

5. Primary optic atrophy and loss of smell for which no adequate cause can be found are always an indication for encephalography.

6. In the future the diagnosis of the cribriform plate meningiomas should be made more early.

7. If surgical interference is undertaken before the growths are very large, the operative mortality rate should be very small.

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THE IMMEDIATE TRANSPLANTATION OF BONE, CARTILAGE AND SOFT TISSUES IN ACCIDENT CASES.

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The matter of transplanting bone, cartilage and soft tissues immediately after these have been destroyed by accidental traumatism, is one of great importance and demands a high degree of discrimination on the part of the surgeon.

Owing to the alarming increase in the number of automobile accidents chiefly, and to the multitude of mechanical innovations incident to the Machine Age, the question as to whether, in a given case, immediate transplantation of tissue is feasible and offers fair prospects of success or whether he should postpone plastic procedures until a later period, is one that the surgeon may be called upon to answer at any time. Upon his correct interpretation of the various factors that influence, in each individual case, the viability of the transplant and its incorporation in the cellular economic system in its new position, depends the success of the procedure; it being assumed, of course, that the technical details of the operation are carried out with precision by a man experienced in this field of surgery.

Though a pioneer advocate of the use of bone and cartilage as a transplant and though many years of experience in the use of these tissues has added to my knowledge of their metabolic peculiarities and the limits of their usefulness as transplants, I feel that I must admit temerity when I discuss the *primary* use of transplants in accident cases. I do feel, however, that my conclusions may be worthy of record since they are drawn from personal clinical experiences spread over a sufficient number of years to merit substantiability.

It is unnecessary for me to remind those who are familiar with my work and my various writings upon this subject, that I use only autogenous grafts, whether they be soft tissues

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from some other part of the patient's body or bone and cartilage from the rib. The grafts, after severance from the body, are transferred as quickly as possible to their new position. Unnecessary handling is avoided and all contacts with the tissues, both of the graft and those at the site of implantation, should be instrumental.

Occasions *do* arise where it is possible to transpose, with reasonable assurance of its viability, either soft tissues or bone and cartilage immediately after an accident in which there has been destruction of tissue. However, even though every precaution is taken in order to secure a sterile field, I must admit that the chances of infection and consequent loss of the implant are far greater than they would be after the danger of possible primary infection of the wound at the time of the accident has passed.

The advantage to the patient is great when the operator is enabled to make a complete, permanent, primary repair immediately after the accident. One is certainly tempted to try to do this, especially when he realizes that ultimately, if not at the time, he must resort to transplantation in order to supply tissue needed for restoration of the part.

Assuming that we are dealing with an automobile accident in which the patient's nose and face have been injured and there has been a loss of tissue sufficiently great to demand replacement: If the plastic surgeon has had early access to the case, the problem that confronts him is whether or not he is justified in attempting to give the patient the advantage of an immediate restitution of the parts that have been destroyed, even though he knows that he must resort to the transplantation of tissue, one of the prime requirements of which is a sterile operative field. It is, of course, unnecessary for me to say that this condition cannot be met with certainty under any circumstances, but undoubtedly favorable opportunities do come to us and it is the part of wisdom to take advantage of them.

General factors, such as the age of the patient, his freedom from constitutional disease or upper respiratory infections, (if the nose is injured), his vital resistance, the degree of shock attendant upon the accident, the amount of blood lost, etc., all have obvious important bearing upon the management

of the case and will, of course, be given proper consideration by the careful clinician.

If there has been complete amputation of the nose and the severed member can be immediately secured, an attempt should be made to graft it upon the stump. It is reported that this procedure has been successfully carried out in India, where amputation of the nose was the penalty for certain crimes. It was claimed that on several occasions the severed member had been recovered by the culprit and so skillfully grafted to the remaining stump that he escaped the intended punishment. On this account the law had to be changed so as to include the destruction of the nose after it had been amputated.

In view of my own failures in grafting on noses that had been completely severed from the body from one to three hours, I am inclined to consign this story to the realm of romanticism and its author to the category of liars.

Since tissues usually needed for transplantation, namely skin, bone and cartilage, vary in their adaptability for this purpose in degree of viability and resistance to infections, the question as to whether or not immediate transplantation should be attempted, other factors being favorable, may depend upon the kind of tissue that has been destroyed and the importance of its immediate replacement in order to secure a satisfactory functional and esthetic result.

I have found that primary skin grafting is usually successful if the hemorrhage has been stanched and if strong antiseptics have not been previously applied to the wound. If, however, a soft tissue graft of any considerable thickness or size is to be used, one must be very careful to apply the proper amount of continuous pressure by means of thin layers of sponge rubber.

If it transpires that a primary infection, introduced at the time of the accident, was not eradicated, we may be sure that the transplant will be lost. In this event no grafting operation should again be attempted until the infection has been controlled and the appearance of healthy granulations indicates that a favorable time for this procedure has arrived.

In the transplantation of bone and cartilage primarily, following accidents in which these tissues have been destroyed

and in the correction of old, established saddleback nasal deformities, I have had much experience, for I first called attention to the advantages of bone and cartilage transplants many years ago. Since this time the use of these tissues has been accepted as enthusiastically in the field of general surgery as in rhinoplastic work.

I have had ample opportunity to observe the response of both bone and cartilage to pyogenic infection, for I have used these tissues in fresh injuries that proved to have been infected at the time of the accident and also in the correction of old nasal deformities where infection was accidentally introduced; my evaluation of their relative degree of resistance to infection, therefore, is drawn from personal clinical experience, hence my confidence in the deductions I have made; they may be briefly stated as follows: — Bone and cartilage are equally intolerant of pyogenic infections; the clinical results, however, differ.

If cartilage is infected the vitality of its cellular elements is destroyed throughout the entire structure of the graft and it must be removed. It is an extremely difficult matter to control the infection and retain the graft. If, for any reason, it should be considered advisable to attempt to save the implant and one should succeed in doing so after prolonged, tedious treatment by means of antiseptic irrigations, the cartilage will surely be absorbed and replaced by connective tissue; the contraction of the latter will be followed by some detraction in the final results of the operation.

On the other hand if a cartilage transplant is introduced into a sterile wound its cellular activities apparently remain undisturbed and it participates normally in the metabolic processes in its new location and remains indefinitely just as it was the day it was introduced, save for the normal changes that occur in its density and its calcium content with advancing years. I know this to be true, for on more than one occation I have found it necessary to remove a portion of cartilage transplants from the noses of patients who had had subsequent accidents in which their noses had been injured and were in need of surgical attention. In one case the cartilage had been in position for three years and in another five years. Microscopical sections of the fragments of cartilage removed showed that no histological changes had occurred in them.

The gross appearance and physical character of cartilage that has long been subjected to infection, is that of a chalky substance. The uniformity with which its entire thickness is devitalized apparently is due to the fact that cartilage is homogeneous and is nourished by means of intercellular circulation; it contains no blood vessels.

In the experience of every man who does any considerable amount of surgery occasional accidental infection of the operated area occurs. We may, by the strict application of the principles of aseptic and antiseptic surgery, reduce that risk to a minimum, still it remains and ever will. In view of this fact, the plastic surgeon should be no less careful in the selection of the material to be used as a transplant in an accident case than he is in choosing the occasion for the employment of primary reconstruction by this method. Other considerations being equal, resistance to infection should be an important factor in making his choice of the tissues at his disposal.

Many years ago I introduced a modification of my original bone-transplantation operation which is intended to preserve the resiliency of the nasal tip, while at the same time it insures the rigidity of the bony portion of the nasal bridge. I called this the *conjoined bone and cartilage* operation for the correction of "saddleback" and other depressed deformities of the nose.

Whenever infection occurs in one of these operations the relative degree of vital resistance of bone and cartilage is shown admirably and under identical conditions.

In every case of infection a portion, if not all of the transplant was destroyed. On several occasions, however, after prolonged irrigation of the infected wound I was able to save a portion of the bone, but only after the cartilaginous portion of the implant had been removed.

I may say here that my combined bone and cartilage grafts are taken from the patient's rib at the costochondral junction. The section removed is split and the outer half with its covering of periosteum is used. The perichondrium, however, should be removed, otherwise it will cause the cartilage to curl up in the direction of the perichondrium. I have made use of this peculiarity on more than one occasion where the nasal tip was unsupported and was badly depressed. By retaining the peri-

chondrium I found that its tendency to curl greatly assisted in raising the tip of the nose.

A bone transplant that has suffered accidental pyogenic infection and the operator has succeeded in controlling the infection without removing it, presents a characteristic appearance in a stereoscopic X-ray film that is made with a soft tube six months or longer after it has healed in. The portions of the transplant uncovered by the periosteum, *i. e.*, the sides and undersurface, present a dendritic appearance, showing that the main body of the implant, that portion protected and nourished by the periosteum, has survived the infection, while those unprotected by this membrane show that irregular areas of bone have been devitalized by the infection and have subsequently been absorbed.

Fortunately the preservation of the outer surface of the transplant throughout its entire length by the periosteum, insures the integrity of the nasal contour in its corrected position, for the periosteum proceeds to deposit new bone to the limits of the demand placed upon it in the process of elevating a sunken nasal bridge.

It is a well known fact that the growth of bone is stimulated and its expansion regulated by the stress placed upon it. It is owing to this important characteristic of bone development that there is no overgrowth of the transplant.

I have purposely deviated from the subject under discussion because it is advisable for one contemplating the use of a transplant as a primary procedure, shortly after an accident involving the destruction of tissue, to know the usual reaction to infection of the several tissues commonly used for this purpose, for one can never be sure of his ability to sterilize any wound, and least of all, those received in accidents.

If the nervous shock, due to the accident, is great, even though no serious injury to any vital organ has been suffered, it is never advisable to prolong the period of physical depression by indulging in complicated, tedious plastic procedures. It is much better to wait until the wound has healed and the final results of the emergency work at the time of the accident, has been evaluated.

One should not wait, however, until the primary redness of the scar has disappeared and cicatricial contraction has occurred.

It has been my experience that an even surface can be secured more easily and that it is necessary to undermine less of the tissue adjacent to the scar if plastic procedures are begun early in those cases where permanent adjustment was not made at the time of the injury.

Implantation of neither bone nor cartilage should be attempted if the tissues are bruised unless there is a superabundance of healthy tissue nearby and it is feasible to excise that which is injured.

Bone and cartilage should not be implanted in a bed of scar tissue as the latter is so utterly devoid of blood vessels that it will not favor its viability.

If rigid or semi-rigid tissue is needed in a situation where it is impractical to remove all of the scar tissue, I have found that cartilage is preferable to bone; this is due to the fact that its nutritive requirements are less exacting than those of bone, which demands a capillary circulation, while cartilage, owing to its intercellular circulation, is capable of being nourished by the serosanguineous pabulum by which it is surrounded in its new position.

Despite the forensic eloquence of those who are continually expounding the theories advanced by the collaborators of text books who frequently give us no facts established by personal investigation and experiment, I am inclined to believe what I see clearly demonstrated in the work I have been doing and which is familiar to most of those who are interested in this subject.

An autogenous graft taken from the rib and implanted into the bridge of the nose in the manner I have frequently described, remains alive, being first nourished by the serous pabulum by which it is surrounded and later by the means of blood vessels derived from the surrounding tissues.

The transplant participates in the metabolic processes in its new position; its growth here, as with bone in other parts of the body, is regulated by the amount of stress that is placed upon it and corresponds to the functional demands of the part.

Many of my transplantation cases have been carefully studied under the X-ray. The films were made at intervals over a period of several years, in some instances as long as

15 years after the operation. We have never been able to detect any evidence of death of the transplant, nor have we been able to recognize absorption and replacement by new bone or fibrous tissue, as has been claimed to occur by many writers. We would like to know how such a process could be determined under the X-ray.

It is unfortunate that experimental work identical with mine upon the human subject cannot be carried out upon lower animals. I feel quite sure that aseptic conditions and complete immobilization of the implant could not be maintained in operations of this kind upon the noses of dogs and that other considerations equally potent would render animal experimentation of no value in this work.

It may be that the unusually favorable surroundings that a properly placed bone graft enjoys, when implanted in the nose, dominates the situation and give results that cannot be duplicated in parts of the body that are not so richly supplied with blood vessels. It is a well known fact, too, that the tissues of the nose are, in a healthy individual, immune to the infectious agents normally present in this area. It must be remembered also that the remarkable vascularity of the nose enables it to recover from severe traumatic injuries more quickly than other parts of the body less favored in this respect.

I have never transplanted bone in any other area than the nose. I have always used a section of the rib of the patient, taken at the costochondral junction. The full thickness of the rib is removed, the periosteum on the outer surfaces being preserved. The section removed is then split longitudinally and that portion covered by periosteum is shaped for implantation. The bulk of the graft consists of cancellous tissue, for the layer of compact bone at this point is very thin. It is thickly studded with nutrient foramina, which is favorable to our purpose. We may be sure that such a graft presents unusually favorable opportunities for vascularation and that if the technique is correct, its viability is practically assured. It will not be absorbed, for it continues to be a part of the living body in its new position.

In summarizing the factors that influence our attitude when dealing with injuries to the nose involving extensive destruction of tissue and it is realized that the grafting of bone and

cartilage, if not accomplished primarily, must be resorted to later on, the following facts should be considered: — Every accidental wound should be regarded as infected.

The operative field should be considered unsuitable for the grafting of any kind of tissue, unless the surgeon feels reasonably certain that the wound is of such a nature that he can render it sterile by the liberal use of soap and water and normal salt solution.

All so-called antiseptics, it should be remembered, if used in sufficient strength to destroy pathogenic bacteria and their spores, also destroy tissue, annihilate the capillaries and inhibit normal cellular activity.

I regard with disfavor the use of chemical antiseptics in any fresh, open and well drained wound, but when the grafting of tissue is contemplated, whether it be bone, cartilage or soft tissue, the previous use of antiseptics, for reasons that I have already mentioned, will have rendered the operative field absolutely unfitted for such a procedure and it should not be attempted, for the implant would probably die from lack of nutrition, even if effective sterilization had been accomplished.

140 East 54th Street.

COMMUNICATION.

August 7, 1935.

DR. MAX A. GOLDSTEIN,
St. Louis, Mo.

Dear Dr. Goldstein:

In the May, 1935, issue of THE LARYNGOSCOPE, page 347, appears an article, "The Chemical Composition of Secretions from Allergic Rhinitis and Sinus Exudates," Catherine C. Buhrmester, M.S., St. Louis.

In the body of the article, page 351, some investigations that we have carried out with reference to this subject are commented upon. Because of these comments and conclusions, I have requested H. O. Nicholas, Ph.D., Instructor in Chemistry, Rice Institute, and who personally carried out the biochemical investigations in our study, for any comments he had to offer with reference to the variations in findings as published by Miss Buhrmester. The following is Dr. Nicholas' report, and I am enclosing them to you, requesting that they be given publication at the earliest possible moment:

"In a recent paper, Buhrmester[1] reported on the chemical composition of the exudate from suppurative maxillary sinusitis. Her results, especially the calcium values, were somewhat at variance with a series of calcium analyses made by the present writers several years ago.[2] Buhrmester's calcium values averaged 8.9 mg. per 100 gm. of pus on 33 analyses (Table II, p. 350). Our results showed 73 mg. per 100 gm. pus in 27 observations.

"It will be noted, however, that Buhrmester's pus samples varied in size from 0.5547 gm. to 3.8393 gm.; with 10 specimens weighing between 0.5547 and 1.0 gm., seven between 2.0 and 3.8393 gm., and the remainder between 1.0 and 2.0 gm.

"In our series of 27 specimens, the size of sample ranged from 0.072 to 10.0 gm., with 20 samples weighing less than Buhrmester's smallest sample,

1. "The Chemical Composition of Secretions from Allergic Rhinitis and Sinus Exudates," Catherine C. Buhrmester, M.S., St. Louis, The Laryngoscope, Vol. XLV, No. 5, May, 1935.

2. "Chemical Composition of Pus from Sinuses," Sidney Israel, M.D., and H. O. Nicholas, Ph.D., Houston, Tex., Arch. of Otolaryng., Vol. 18, pp. 770-774, Dec., 1933.

i.e., 0.5547 gm.; with six falling approximately within the minimum and maximum weights of her samples, and one specimen weighing 10 gm. The average calcium content of our six specimens weighing between 0.5 and 4.0 gm. is 29 mg. per 100 gm. of pus.

"We cite these data to bring out one of the points in our paper, namely, that the size of the pus sample seems to bear an inverse relationship to its calcium content. In fact we plot a curve showing that the larger the pus sample the smaller the calcium content. As we remarked in the paper, 'the possibility of such a factor did not occur to us until recently and, therefore, needs further elucidation before a complete understanding can be had.'

"If one looks at our curve (p. 773) showing the relationship of calcium content to the size of the pus sample, one will note that all of Buhrmester's specimens fall on that part of the curve where the 'mg. Ca/100 gm. pus' tends to be smallest."

SIDNEY ISRAEL, M.D.